PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

ENGINEERING EDUCATION

VOLUME 58

1950–51

PUBLICATION COMMITTEE:

THORNDIKE SAVILLE, F. M. DAWSON, A. B. BRONWELL (EDITOR)

OFFICE OF THE SECRETARY
EVANSTON, ILLINOIS
1951

LANCASTER PRESS, INC., LANCASTER, PA.

Francis M. Dawson, President, ASEE, 1950-51

President F. M. Dawson was born in Nova Scotia on September 3, 1889. He graduated in civil engineering from the Nova Scotia Technical College at Halifax in 1910, and three years later was granted the degree of M.C.E. by Cornell University. His military service during World War I involved over four years of active duty, primarily with the Canadian 8th Engineer Battalion as Captain and

Adjutant. Directly before and after the war he spent four years on general construction projects.

He began his teaching career in 1921 as an assistant professor at Cornell University, becoming in 1922 Professor of Hydraulics at the University of Kansas, in 1928 Professor of Hydraulic and Sanitary Engineering at the University of Wisconsin, and in 1936 Dean of Engineering at the State University of Iowa. The Schoder-Dawson book on "Hydraulics," has been a standard text for many years, and the Dean is also author of the hydraulics section in O'Rourke's "General Engineering Handbook" and of numerous technical papers.

Dean Dawson was a vigorous promoter of the Engineering College Research Association, and became the Vice President of the Society and Chairman of the Engineering College Research Council when it merged with the ASEE. He was reelected to this post two years ago. Through his efforts on the Research Council, he has taken an active part in promoting the adoption of the National Science Foundation legislation, as well as other legislative programs relating to engineering and engineering education. Under the leadership of Dean Dawson, the Research Council has established committees on Relations With Military Research Agencies, Non-Military Research Agencies, and Industrial Research Agencies, and has also published a number of significant reports, including the Proceedings of the Research Council and the Directory of Research. For the past two years he has served as the Society representative to the National Research Council.

His membership in some ten professional societies includes, in addition to the ASEE, the ASME, ASCE, AWWA. AGU, and AAUP. In many of these he has held important offices, principal among which were the presidencies of the Central States Sewage Works Association in 1938, of the Iowa Engineering Society in 1940, and of the Engineering College Research Association from 1946 to 1948.

Dean Dawson's many years of service to national, state, and municipal organizations are distinguished by his contributions to the American Standards Association, the National Resources Planning Board, the Army specialized Training Program, the Iowa Natural Resources Council, the Iowa City Chamber of Commerce, and many other state and National Committees. He is Director of the Iowa-Illinois Gas and Electric Company and the Iowa Water Service Company and is Chairman of a National Plumbing Code Coordinating Committee.

Editorial

By F. M. DAWSON

President of ASEE and Dean, College of Engineering, State University of Iowa

That we are moving through dangerous and stirring times is generally acknowledged, but it is not so generally known that we have for guides a series of comprehensive studies dealing with the direction in which our nation is going. These investigations have not been well publicized, and furthermore it is not at all certain that our governmental officials will follow them. However, of greatest importance to the faculties of the colleges and schools of engineering and technology are the studies made by committees of our own society. The reports of each committee should be closely examined and I suggest that each school should devote at least one faculty meeting to a discussion of the pros and cons of the following reports:

(1) Report of the Investigation of Engineering Education (1928–29).
(2) Report of Committee on Aims and Scope of Engineering Education (March 1940).
(3) Report of Committee on Engineering Education After the War (May 1944).
(4) Education for Professional Responsibility (Carnegie Press, April 1948).

Your society has a strong committee under the chairmanship of Professor L. E. Grinter now working on a study for "The Improvement of Teaching." This committee will certainly bring forth stimulating ideas for the improvement of our work. First and foremost we should be good teachers.

From a Canadian university comes a significant statement of policy which is worth repeating, and though general in scope, is may be applied specifically to engineering. It is wise to go back to a consideration of basic principles particularly now when we are making an effort to enrich our program for all types of engineering education.

> "There should appear at the outset a carefully defined set of principles around which the functions of the various faculties revolve. Those principles, which apply with such vigor to higher education may properly be recorded here.
>
> "First, a university is an association of scholars devoted to teaching and research.
>
> "Second, a university is a school for the training of the mind, based on the assumption that a proper development of the intellect is required for the full life of man and for the improvement of society at large.
>
> "Third, a university is an institution which offers instruction in certain kinds of professional knowledge and skill, by which the student may afterwards earn his livelihood and contribute to what Bacon calls 'The relief of man's estate.'
>
> "Fourth, a university is an agency which enables each new age to enter into the fulness of its cultural heritage."

In these momentous years, ASEE will continue its work of providing a means through which teaching in all colleges and schools of engineering and technology can be continually improved.

Engineering Education in a Changing World*

By THORNDIKE SAVILLE

President ASEE (1949–50);
Dean, College of Engineering, New York University

"Times change and men change with them": So also must education change to prepare men to cope with changing times—education in its proper sense—not the mere communication of knowledge, but the discipline of the intellect and the establishment of principles. Engineering education is the most complex and the most sensitive to social and political considerations of any of the professional disciplines, for while law is based primarily upon interpretations of past decisions of the courts and medicine is chiefly devoted to the skillful applications of science to the individual human body, engineering is concerned on the one hand with the practical application of the natural sciences to the use and convenience of man and on the other hand to the implications of economics and of sociology upon the operation and control of engineering works and devices.

Engineering education has perforce to be fluid, and this Society has always been prompt to relate the basic premises and curricula of engineering education to realistic appraisals of changing times and needs. Four epoch making reports of the Society bear testimony to this: "Study of Engineering Education" (1918), "Investigation of Engineering Education" (1929), "Aims and Scope of Engineering Curricula" (1940), and "Engineering Education after the War" (1944). A scrutiny of present committee activities will indicate that the Society continues to be alert to the pressures of changing conditions upon engineering education.

*Presidential Address, Annual Meeting of the American Society for Engineering Education, Seattle, Washington, June 1950.

Dynamic Influences Affecting Engineering Education

Engineering is alone among the recognized professions in not requiring more than four years of formal education for the majority of its practitioners. The physicist, chemist, or biologist as well as the doctor, or lawyer, or clergyman is ordinarily expected to have had one or more years of post-graduate study. On the one hand engineering is applied science. Each new advance in science, and science is expanding with bewildering rapidity, creates new potentialities of application which sooner or later must be reflected as an addition to engineering education. On the other hand engineering is applied economics, applied sociology, and sometimes applied politics. Each new concept of decreased working hours, higher wages, more recreation, increased agricultural development, improved working conditions, housing, conservation of natural resources, etc. has its effect upon the design and operation of great engineering works, an effect which must be reflected to some degree in engineering education. The engineer must be competent not only to apply to science but to apply it with some knowledge of its economic and social effects, else he will not design or operate in the best interests of society.

In all this we are merely educating a student for a profession. Nothing has been said of his education as a citizen. There are peculiar responsibilities of the

engineer as citizen, *because* he is an engineer. A distinguished past president of this Society has said "we are living in a remarkable age, an age different from any that has preceded it in the history of the world, and one in which changes are taking place with marvelous rapidity. As a profession we are largely responsible for the present conditions, and therefore we should do our part in solving such problems as exist, and in helping to direct the tendencies of the day. We have a duty to ourselves, to our profession, to society, and to our successors, and we must perform it." I am sure that you are trying to guess which of my immediate predecessors made this observation, so apropos of our profession in post World War II days. It was not made even of post World War I days. It was made by George Fillmore Swain, in an address given in 1913, thirty-seven years ago. I am quite certain that one or more of the distinguished speakers today will make similar observations. That is because what was true in 1913 is even more obvious today when engineering has come of age, when engineers occupy an increasingly influential position as scientist-citizens.

No wonder that we who are responsible for the professional education of engineers are somewhat bemused at the admonitions we receive from our well-wishers. The executive of a great industry wishes our graduates, who are to succeed to management of his enterprises, to write well, to speak well, and to be broadly grounded in both the science and techniques of our profession. They put scientific and specialized knowledge well down on the list of desired attributes. The employment officers of the same corporation offer priority jobs to our graduates if they have had the latest speciality in their curriculum in electronics, soil mechanics or nuclear physics. Certain government agencies want to know if our graduate-applicants are in harmony with the social or economic objectives of this or that agency. Some of our speakers today will urge that we take more time to inculcate in our students ideas of participation in public affairs, of the opportunities for government service, of our international responsibilities as engineers. A year ago industry was represented here, and eloquently told us of the perils besetting the private enterprise system, of the obligation of engineering education to train its disciples in "sound" economics, and the like.

Because of the dual role of the engineer as applied scientist and as manager of industrial and public works we are certainly an unique profession with great opportunities for professional satisfaction and for service to society, but as engineering educators we have long been placed by our diverse well-wishing advisers upon the horns of a dilemma, the compromise between the physical and the social sciences, and never more so than today.

It would be nice if we could teach and indoctrinate all these desiderata. But we can't put everything in the curriculum. I mention curriculum because that is where most of our critics begin their diatribes upon engineering education. Of course there are some minor (!) problems of competent faculty, adequate facilities, student guidance, and the like but generally it is thought that all would be well if we just put in the curriculum all of the things which each critic felt would make a well grounded engineer and of course all in four years.

Technologists or Engineers?

However, the curriculum is merely the machinery by which we implement our philosophy of engineering education. Engineering as a profession occupies a middle ground between technology and science. A middle ground both geographically and philosophically is that which is occupied by the greatest number of people. There are many in this audience who will dispute the latter statement. They will refer to studies and polls and reports which indicate that there is need for three to ten times the number of subprofessional personnel auxiliary to engi-

neering as there is for engineers. It is maintained that this auxiliary personnel can be and should be trained by two year terminal courses. This Society's famous report on "Education After the War" points out that in practice "the relative numbers of individuals trained for subordinate technical positions in this country in comparison with engineering graduates is in inverse proportion to the needs." In spite of the impetus which this and other reports have given to the establishment of technical institutes, in spite of the expanding needs for both technicians and engineers, the situation as to relative numbers being trained and educated remains substantially unchanged.

Our philosophy does not appear to be in accord with the facts of life, and perhaps we should re-examine our philosophy. In the first place it seems to me that there is a carefully unexpressed but nonetheless implicit supposition abroad that young men and women seeking to prepare themselves for a career in which a basic education in technological and scientific subjects will be useful can be compartmentalized at the outset; that of a given number of such high school students we may say that 20% should terminate their formal education upon graduation, that 40% should terminate their education by means of a technical institute program, and that the remaining 40% should complete at least a four year college program preparatory to engineering or physical science. The percentages may be all wrong, but the idea is there.

I submit that this idea is unsound, even if by some different and better philosophy the percentages remain the same. The idea is not consonant with a democratic society in which free choice of an occupation is paramount, free choice to try and if necessary by competition to fail. Furthermore, it is predicated upon an equally erroneous idea that we have test procedures by which we may guide young people into the careers for which they are best fitted thereby preventing the frustrations and dissatisfactions attendant upon failure. As yet, we have no tests of sufficient precision to warrant this. Available tests may help but they do not determine. And what of the frustrations attendant upon those persuaded to embark upon terminal two year programs who are discovered subsequently to be capable of pursuing engineering education and find that they have in essence to start all over again in the freshman year if they wish to study engineering?

Then there is the supposition that the draftsman, the surveyor, the inspectors, the "minor industrial supervisors," etc. do not require a four year engineering course, that in effect they would be wasting their time and their own or someone else's money. Who can say that people in these occupations, if engineering college graduates, *have* wasted time or money? May they not be more useful, as well as happier and better citizens? *Must* they be frustrated because they have not climbed to the top of the ladder? Moreover a distinguished engineer has recently observed that "many mechanisms formerly handled by technicians have become so intricate that they are now beyond the understanding of any except graduate engineers."

Compartmentalization or Integration

Finally, there is already apparent a tendency to merge the technological institute with the junior or community college, or to create the latter out of the former. We have as useful and stimulating groups in this Society a Division of Technical Institutes and a Committee on Junior Colleges. Their separate and joint discussions have indicated uncertainty as to respective well defined separate functions.

Let us be frank. Again one of the publicly unexpressed but implicit philosophies of the interest which some of us have expressed in the Technical Institutes may perhaps have been to recognize them as a growing force, to even give them standing by accreditation through the Engineers Council for Professional Development, and thus keep them in a

respectable but carefully circumscribed compartment, so that their ambitions would not lead them to become additional and perhaps inferior four year engineering colleges. We thus tacitly recognize that able and intelligent young men, urged on by an able and ambitious faculty, are likely not to be content with enforced compartmentalization. On the other hand let us be equally frank with respect to some of these two year colleges. Evidence exists that in too many instances certain of their students have been badly advised if not misled into sincerely believing that their present curricula, particularly in some technical institutes, are quite the equivalent of the first two years in an engineering college. Such is generally not the case at present, and many heartbreaks would be avoided if some of the faculty of these institutes and colleges would advise their students more fairly and realistically.

Oliver Wendell Holmes says in his "Poet at the Breakfast Table" that there are "one-story intellects, two-story intellects, three-story intellects with skylights. All fact collectors, who have no aim beyond their facts, are one-story men. Two-story men compare, generalize, using the labors of the fact collectors as well as their own. Three-story men idealize, imagine, predict. Their best illumination comes from above through the skylight." Here, it seems to me we have those who should terminate their post high school education in two years, those who should complete a four year engineering course, and those who should go on to postgraduate work.

Therefore, to return to the basic philosophy of engineering education, I believe we should expand the leadership already shown by so many of our prescient leaders who have concerned themselves with the place of technical institutes in engineering education. I believe we must bring our influence to bear, and promptly, upon the state educational systems to reduce this compartmentalization, and to integrate so far as possible the pre-engineering aspects of the technical institute, and the junior and community colleges, into a broad all-embracing program of engineering education.

Let engineering education enlarge its responsibilities and take into the fold as partner, not as step-child, these lusty youngsters. This harmonious partnership is well under way in California. It can most readily be accomplished under the great state university organization in effect there. It will be more difficult in the eastern states where as yet the great state university systems are a cloud on the horizon. But this is an ominous and growing cloud for many privately endowed engineering colleges, and in their own interests as well as from a sound educational philosophy the problem must be met. Nor is this cloud to be ignored by those state institutions who presently dominate engineering education in their regions. The growth of community colleges and technical institutes, if not integrated with the engineering education process, will result in dissipation of taxpayers' money and ultimate weakening of the support and performance of engineering colleges.

It is not possible nor feasible here to give the details of what I mean by "integration." Broadly I suggest that we proceed to re-examine our curricula, and to inspire changes in the curricula and the procedures of the two-year terminal programs to the end of greater flexibility. Let us provide a constant interchange of goodwill as well as of students. Let us not shackle two- and three-story men in two year programs so that ultimate achievements to which their latent talents entitle them are denied them by too great expenditures of time and money.

Rigidity of the Engineering Curricvlum

Of course this brings me to the engineering curriculum, one of the chief subjects of study by many distinguished committees of this Society. In spite of numerous exhortations to the contrary undergraduate engineering education remains in general conventional, compartmentalized, static, and unimaginative. It

does not reflect adequately the dual role of the professional engineer as described previously. It is rigorous, competent, sincere, and designed well to produce immature specialists immediately useful to their employer if there is a particular specialist job available. It does not provide adequately for the transfer of competent students from two-year community colleges or technical institutes. It does not provide for sufficient basic science or even basic engineering. It rushes through rigidly prescribed courses with few free electives in either the humanistic-social studies or in engineering. It assumes that a young man knows by the junior year, and in an increasing number of cases by the sophomore year, that he wants to be a civil, electrical, or chemical engineer. It then chains him to that curriculum making any later change most difficult. In short it ignores many of the profound and sensible recommendations of the "Report on Aims and Scope of Engineering Education" published by this Society ten years ago. Let me quote just one recommendation of that report: "Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the post-graduate period where it may be pursued with a rigor consistent with preparation for engineering specialization." I fear there has been almost a contrary tendency in some of our curricula.

I have deliberately overdrawn the gloomy side of our curriculum situation, because I felt that it is high time we shocked ourselves into an objective reappraisal of our philosophy of engineering education and of the means by which we implement that philosophy. If we are "to educate" as distinguished from "to train" our future engineers I think we have to recognize more clearly the dual role which we have; that on the one hand as applied scientists we require ever more fundamental science; that on the other hand as managers of industry and of public works and as citizens we need more selection and breadth in our education.

Current Trends in Engineering Education

Early this month I attended a meeting sponsored jointly by this Society and by the Atomic Energy Commission to conduct an initial exploration as to the education required for engineers who are to participate in the design, construction, and operation of structures and devices connected with the use and control of nuclear energy. Five deans of engineering schools from five widely separated regions of this country seemed to agree with the pronouncement of one of them to the effect that the day had about gone by when an undergraduate, or perhaps even a graduate, should be educated as a specialist in a given branch of engineering. It was felt that the time he spent in college, whether four or more years, should be devoted to giving him a fundamental background in different aspects of engineering and science, and that the 10% more he needed to become a real specialist he would get by himself later. I did not understand by this that there was a proposal to educate all engineers to a pattern, but that there should be greater uniformity in undergraduate engineering education to provide the greater fundamental background and breadth of outlook to the end of greater versatility at the end of four years, and a better foundation for graduate study if he continued his education beyond the first degree.

Two years ago I ventured a proposal for a new type of undergraduate engineering education in a paper before a Division of this Society. Briefly this envisioned a nearly uniform three year program, adapted on the one hand to interchange of students with two-year colleges and institutes, and on the other hand to a broad fundamental program of science, engineering and the non-technical studies designed to prepare for *any* career where a college education was required or desirable. At the beginning of the senior year some students would elect a largely non-scientific technical year to end their formal engineering education and be prepared to enter a great

variety of occupations where further engineering study was not required. The others would by aptitude and particular abilities then take their fourth year as beginning specialists in a given branch of the profession. Both groups of fourth year students would have many electives in their respective fields, both would receive upon graduation an undesignated Bachelor of Engineering.

The applied science group would expect to go on for a fifth year, also with electives, to receive their first designated degree in a given engineering field. This is not the place nor time to present arguments for such a plan, nor is this the only plan suggested to work major changes in our conventional engineering curricula. Other approaches are already under way in a handful of institutions. But time is running out, and as a group we must be bold and imaginative if we are to adapt engineering education to meet the needs of our country and to enable our graduates to take the places in society to which they aspire.

This brings me to say a word about our faculties, for any kind of education is no better than the men directing it. The ideal instructor is first of all a specialist, yet with a broad outlook on the whole educational horizon. He is a scholar, yet with attributes of an engaging personality. He is a skillful and inspiring teacher, yet with interests in public affairs. He is engaged in research, yet not indifferent to administration. With our faculty as with our curriculum we have to compromise, and also may I add with the attributes of our engineering college administrators! But it is necessary to compromise, and if I have any plea at all to make here today it is to urge the great body of our membership, constituting the democratic arbiters of policy and curriculum, that they do evince a willingness to compromise, for only by compromise between established shibboleths of the past and the visionary ideals for the future many we attain a practical and improved education for the present.

Preparation for Public Service

For many years the chief thread which has run through the studies and reports on engineering education was our responsibility to train for industry. Last year the keynote of the general sessions of the Society was Relations with Industry. Due in part to the initiative of my immediate predecessor we have a recently created, active, and effective Division of the same name. This year it seemed opportune to me to put more emphasis upon our relations with Government. Increasingly as government on all levels takes over more and more enterprises of an engineering character, a greater proportion of our graduates enter public service. We are to have addresses today and tomorrow night from engineers who have distinguished themselves in various fields related to government or to national policies. The Society must perforce give more attention to such matters. We have a number of committees dealing with specific government relations, such as research and military affairs. However, there are many general problems before us where government activities, especially those of the Federal Government, may profoundly affect us, and where we can contribute powerfully to guiding public policy. We took a positive and purposeful stand on the Science Foundation Bill, which is now law. We should participate energetically in the more nebulous problem of planning for use of our facilities, our staffs, and our students in the event of a national emergency. Such planning seems sorely absent in Washington, and we should insist on stimulating it. Various acts of Congress, such as the Point Four program, open up spheres of usefulness to us on an international scale.

Speakers to follow me will be better informed and more eloquent that I in pointing out opportunities in government, in international affairs, and in public affairs. But I wish to re-emphasize the exhortation of Professor Swain which I quoted, and apply it particularly to the

members of this Society. We have not only a general obligation as engineers, but a particular responsibility as engineering educators to participate in these areas of public service.

As life upon the local, national, and international level becomes more complicated, it requires in general more consideration from engineering educators to relate their responsibilities to the ever-changing, ever more complex scheme of things. I have touched upon a few of our larger problems in what I have said. I am sure that Dr. Bronwell's account of the activities of various of your Divisions and Committees and of your officers during the past year will make it apparent that never has your Society been more alert to all of the many facets which impinge upon engineering education, never have more members labored more earnestly and to better purpose than during this past year. New problems constantly beset us. With good will, with vision, with compromise, with even greater participation by more members of the Society we shall surmount them all. No professional group can have a greater variety of challeging problems to solve of great public as well as educational consequence. No group has greater opportunities to exert a significant influence upon the national economy and welfare. This challenge we shall meet, for we are the servants of society, the bond servants of science.

Reorganization of the Federal Government[1]

By RAYMOND B. ALLEN
President, University of Washington

Gentlemen, you are engineers, you are educators . . . you are also citizens. What I propose to say to you this morning will be important to you, I hope, in all three roles.

First let me formulate, for your consideration, something of my own philosophy of the role of education in the rapidly changing world of today. I think I may say, with all due regard for the other forces directing American life today, that we educators have a tremendous—perhaps the primary—influence in determining the pattern which life in the United States will take in the years ahead. "We have this influence" . . . I should say, rather, than we *can* have this influence, if we exercise the power and responsibility which is ours. If we do not, I must warn you that there will be others—perhaps with less high-minded objectives—who will exercise them for us, and to the detriment of the nation as a whole. What we do in our classrooms, and through the myriad other educational channels at our disposal, may well determine the future course of our country as a democracy. And in an era when that democracy is threatened by a variety of totalitarian influences, our work is more important than ever before.

Peaceful Rebellion Leads to Progress and Stability

In that context, then, let me say to you with all the sincerity at my command that our responsibility is to plant the seeds of peaceful rebellion. For only in rational rebellion—in continued questioning of authority and a constant seeking for better and more effective ways to achieve the objectives of our democratic society—is there any real hope for the perpetuation of that society. Abraham Lincoln, in his first inaugural address, made very much the same point when he declared:

"This country, with its institutions, belongs to the people who inhabit it. Whenever they shall grow weary of the existing government, they can exercise their constitutional right of amending it, or their revolutionary right to dismember it or overthrow it."

This statement, may I remind you, was made by a President of the United States, a man whose primary concern was with preservation of the Union . . . and made, too, at a time when the nation was struggling to maintain its unity and indeed its very life. Yet so strong was President Lincoln's faith in the democratic process that he considered it desirable, at that critical juncture, to restate man's fundamental right to be free even from the restraints of the very government he had created.

Now certainly we may all hope—and I personally believe—that it will never be necessary for the American people to exercise that "revolutionary right to overthrow" their government. For myself, I am confident that our system is sufficiently flexible to permit ordered, reasonable change. But I do contend that unless we encourage in our students the attitude which *welcomes* change—which indeed, actively questions all established dogmas and formulas—unless we do this, I say, we are paving the way for acceptance of

* Presented at the General Session of the Annual Meeting in Seattle, Washington, June 21, 1950.

a pattern of authoritarianism which may destroy our system.

Self Government a Vital Element in Education

The primary business of education is to train people to think. Obviously this is dangerous because there will be those students who never survive to good citizenship . . . but the risk must be taken. It is generally recognized that students must have the opportunity to test ideas in their own experience. This is the purpose of the scientific laboratory. This is why doctors serve internships under expert supervision. This is why students training to be engineers, teachers or businessmen, or professional men do field work to gain practical and necessary experience. And so it is in the area of government as well. To my mind, it is more important, for example, that students should have a substantial measure of self-government in their affairs as students, even though this may mean some unsound decisions, than that they should have all the "right" ways pointed out to them by older and presumably wiser heads. Far better that they should make their own mistakes, and in the process learn how to govern themselves and their fellows, than that they should have "The Truth" imposed upon them by those whose theoretical wisdom stems from longer experience in the affairs of men.

True, there must be some limitations that will keep the socially and politically immature student from doing harm to himself and to others. Teachers, supervisors, parents, business and professional men, and all people of good will, must guide the young during this difficult adjustment. But unless the guidance is provided in an atmosphere of tolerance, even encouragement, for conflicting ideas, there can be no hope of developing intelligent adults properly equipped to take their place as leaders in our society.

This is not an easy philosophy of education to accept. The easy way is the way of authoritarianism. This is the seductive road to totalitarian dictatorship, which leads to human degradation. If we have the faith of our fathers, we shall take the hard way, the way of independent thought and action; we shall guarantee for our children freedom of thought and expression, freedom of questioning and action, thus guaranteeing them an opportunity for the good life each according to his abilities and his merits.

Democracy is not an easy or an idle way of life. It requires that all of us accept our full responsibilities in the affairs of the society of which we are a part. Ours is not a freedom from, but a freedom for. As Thoreau put it, "Be not simply good, but good for something."

I have been very much heartened, during the past year or so, at the widespread and enthusiastic response of the American people to what might be considered a proposal for revolution. I refer to the findings of the Commission on Organization of the Executive Branch of the Government, popularly known as the Hoover Commission. It is encouraging too, in the light of what I have been discussing, that there is substantial interest among the students of our country in the findings of the Hoover Report. Indeed, the national Citizens Committee for the Hoover Report has an active Committee working with high school and college leaders throughout the United States, to bring to the students the facts and conclusions which resulted from the study. This is indispensable subject matter for all studies pointing toward good citizenship.

Assignment of the Hoover Commission

As you doubtless know, the Hoover Commission was created in 1947, by unanimous vote of the Congress, that it had from the start the full approval of President Truman, that its membership was thoroughly bi-partisan including six Democrats and six Republicans, that its chairman was the only living ex-President of the United States, Mr. Herbert Hoover.

The Commission's assignment appeared simple enough: To discover how well or how badly our Federal Government was organized and managed, and with thor-

ough objectivity to recommend the ways in which it could, over the long run, be improved from an operational and management point of view.

The basic conclusion of the Commission was also simply stated, but it carried a severe indictment as well as a glowing challenge to our people: *"The nation is paying heavily for a lack of order, a lack of clear lines of authority and responsibility, and a lack of effective organization in the Executive Branch."*

This was no criticism of any individual, for no one person, no one political party or administration was to blame for the situation the Commission found. The crisis reflected in the Hoover Commission's Report has been brewing for many years, and was a result not of any specific action, but rather of *lack* of action, lack of proper planning, during the decades when the Government was changing in response to changing needs.

Our nation today has—and is paying for—Big Government. Yet Big Government, I contend, is not bad in itself. The United States is no longer, as it was one hundred sixty years ago, a loose affiliation of ex-colonies clustered on the Eastern seaboard, with a population of some three million and an economy largely agricultural. Today, with 150 million people, spread across three million square miles and engaged in a highly diversified as well as a highly mechanized economy, we *need* Big Government. Our nation's domestic problems, to say nothing of its responsibility in world affairs, would stagger Paul Bunyan; and it requires a government of equal proportions to cope with these problems when local and state government cannot deal with them.

Big Government, however, need not be inefficient government—and here is the heart of the Hoover Commission studies. When the Commission was organized, it established twenty-four research committees, known as "Task Forces" and employing the voluntary services of some 300 experienced specialists in various fields of management and administration, to inquire into the facts of structure and organization in the government's Executive Branch. The task force, findings, later analyzed and interpreted by the Commission itself, represent the most complete and thorough-going study our nation has ever had of the management of our government and the defects in its structure.

More than eighteen months after the Commission came into existence, it submitted its final reports to Congress . . . and incidentally returned the unspent remainder of its two million dollar appropriation. In nineteen volumes, the Commission tore the government apart, found what makes it tick, and offered more than three hundred recommendations for making it tick better.

Now it is true that some of the Hoover Commission proposals are highly controversial. It is true, too, that there was disagreement even among the Commissioners themselves on some of the recommendations, with minority as well as majority reports being filed. I do not stand before you today to say that the Hoover Report is an inviolable blueprint for sound government. It does, however, point the way toward intelligent reorganization of the Executive Branch. Many of its proposals are so patently right that they leave virtually no room for argument. Others represent a good starting point for reorganization, with the details to be hammered out by Congress and the President, in response to the wishes of the American people.

Implementation of the Hoover Report

Indeed, a great deal has already been accomplished toward implementing the Hoover Report. To date, in just one year, at least five major bills have been enacted into law, all aimed at providing us with a more efficient and incidentally, a more economical government. The most important were the laws unifying the armed services in a National Department of Defense; establishing the General Services Administration to combine pur chasing functions, records, building management, and war assets disposal; ap-

proving of pay raises for top government officials and improving the Civil Service Classification Act; strengthening the staff of the Secretary of State; and empowering the President, through the Reorganization Act of 1949, to submit plans for realignment of Executive agencies and bureaus. Additional bills of considerable importance, notably in the areas of Postal and Civil Service reform, Accounting and fiscal procedures, are currently awaiting action in the Senate and House of Representatives.

One of the proposed measures which has received comparatively little attention, but which I consider highly important, would create a new Commission, along the lines of the original body, to explore the vast area of Federal-State Relations, with special emphasis on fiscal relationships. Such an inquiry was recommended by the Hoover Commission itself, which acknowledged the importance of the subject but felt it should be studied as an independent matter.

In addition to the legislation enacted or now pending, numerous steps toward governmental efficiency have been taken under the Reorganization Act of 1949. Thus far, the President has submitted 34 specific proposals to the Congress for reorganizing various units of the Executive Branch. On every such plan, the law provides that it shall go into effect sixty days after submission, unless previously rejected by one House or the other of Congress. Of the 34 already sent up by the President, only six have been rejected, fifteen are in effect, and the remaining six are still under consideration. Moreover, the President has indicated that other proposals will be forthcoming.

In sum, approximately 35 per cent of the recommendations of the Hoover Commission have already been effectuated, and with further action expected at this session, the indications are that better than one-half of the recommendations will have become law. This achievement, in little over a year, is all the more remarkable because even the best friends of the Commission said that fifty per cent in *ten* years would be a high proportion to expect.

Reasons For Success

This is indeed an astonishing and heartening record. Authorities on the history of our government are agreed that never before has there been so great and so constructive an achievement toward reorganization, in so short a time. To what may the accomplishments be attributed? I would name several factors:

To begin with, as Charles B. Coates, the general manager of the national Citizens Committee for the Hoover Report, said in Seattle a few weeks ago, "The time was right." Everyone had become aware that our Federal Government, in its vast growth, had developed into an unwieldy and chaotic structure. The impact of depression, war and postwar adjustments had created a vast and unmanageable piece of machinery, and the cogs had begun to slip. Meanwhile, the United States was accepting an evergrowing role in world affairs, and was simultaneously being subjected to pressure from the more highly organized (and *apparently* more efficient) nations of totalitarian bent.

Secondly, among the influences for acceptance of the Hoover Report, I would cite the bi-partisan and high-minded efforts which characterized the work of the Commission from beginning to end. Hundreds of men, with vast experience and tremendous abilities, labored long hours, under the inspired leadership and example of Mr. Hoover and with the full encouragement of President Truman, to evolve an orderly pattern of government without regard for partisan or political considerations. Finally—and this, to my mind, was the over-riding influence—there has been a genuine and enthusiastic response from the American people.

To me, the interest shown by the people of our country in what was, after all, a rather unglamorous and difficult subject, has been the greatest living proof that our democratic system does work.

Thousands upon thousands of thoughtful letters have been sent to Congressmen by citizens in all walks of life; millions of signatures have been affixed to petitions circulated by such public-spirited organizations as the Junior Chambers of Commerce of the United States; there have been countless meetings, discussions, study groups, devoted to the issues raised by the Hoover Report.

Washington State Committee

Much of this interest has been spontaneous. More of it, perhaps, has been generated by the 40-odd citizens' committees, on state and national levels, unselfishly concerned with the promotion of sound government. I have mentioned the national Citizens Committee for the Hoover Report. Let me cite the experience of a group in our own state—the Washington Committee on Federal Reorganization, of which I have the honor to be chairman.

On our executive committee we have conservatives and liberals, educators, businessmen, labor union officials, clubwomen, and representatives of other viewpoints. Because of the diversity of this group's interests, and because of our faith in the basic intelligence of the American people as represented in our own State of Washington, we early decided that we would not attempt to dictate to our fellow citizens what course should be taken. Accordingly, in a Statement of Objectives adopted before our program was launched last year, we said, in part:

"As a committee, we do not favor or oppose any specific recommendations for reorganization of any particular department. Our concern is, rather, to acquaint the public with the problems and issues involved, and with the facts on which our fellow citizens may base their own decisions. Our mission is purely educational. It is the duty of every citizen to study the problems of government.

"It is our conviction that through the program of public information, education and discussion, sound opinions will be formulated on the far-reaching implications of the comprehensive report, and that as a result, legislative and executive action can be obtained which will greatly benefit the entire nation."

This salutary policy of emphasis on education rather than propaganda has proved its value completely in the months that have passed. The response, I assure you, has been most gratifying. We have received expressions of interest and requests for factual information from hundreds upon hundreds of individuals and organizations of every type. Money has flowed in, in the form of dollar bills and small checks, to help support our work, though we have never made a general appeal for financial contributions. I cite this not to show how easy it is to raise funds—for I am sure you know it isn't—but as evidence that there is a genuine, grass-roots interest in the subject of how our government can be made to function more effectively. Volunteer speakers, many of them enlisted for our committee by the board of governors of the Washington State Bar Association, have delivered scores of talks before all manner of organizations and in every corner of our state. Factual literature has been distributed in the thousands of copies, often through the cooperation of such diverse groups as the labor unions, banks, department stores, farm organizations and Parent Teacher Associations.

For me, this tremendous response points to the fact that there is indeed among the people of the United States a very real interest in their government. They *believe* in the democratic system; they want to *make* it work.

The Challenge

And that, gentlemen, is why I open these remarks with a challenge to you as educators and citizens. For if we who are guiding the minds of the young do not provide them with the tools of citizenship, tools in the form of attitudes and techniques acquired as self-governing students in high school and college, then whom shall we blame when they accept

the blandishments of the siren totalitarianism? There are too many authoritarian methods in our schools even yet.

Now as engineering specialists, you may ask what the Hoover Report has to say about the area in which you are professionally interested. It is right and proper that each of us should give primary attention to the subjects with which we are particularly concerned. I must confess that I myself have not read the entire two million works of the Hoover Report—though I have examined carefully the majority and minority findings, plus the Task F rce analyses, in the area of medical services and other subjects which particularly touch my own interests.

On the matter of engineering, the Hoover Report made extensive recommendations to which I can refer only briefly here. Perhaps the most important involved the overlapping and often conflicting activities of the Army Corps of Engineers and the Bureau of Reclamation. Former Governor Miller of Wyoming, has called these agencies "the lobby that can't be licked"—and a member of Congress from the State of Washington recently observed that the crucial test of the Hoover Report's effectiveness would come in precisely this area, for there are solidly entrenched interests in both of these agencies which constantly resist any proposal to change the present structure. Yet it is a matter of record that to prevent the flooding of Cherry Creek, a small stream near Denver, the Army Engineers tore down a dam which local engineers considered adequate, then built another three miles long, 140 feet high and costing 15 million dollars. It is also a matter of record that the Army Engineers and the Reclamation Bureau drew up separate plans for a project at Hell's Canyon, Idaho; each set of plans cost about $250,000, yet they differed in essential particulars of construction and differed, also, by over 75 million dollars in cost of erection.

In the light of these findings, the Hoover Report recommended that the Department of the Interior should be given clear major responsibility for government development of the nation's water and mineral resources; and that, since these activities require large public works, other major public works should also be managed by the department. To these ends, the report observed, the Interior Department should take over the flood-control and rivers and harbors work of the Army Engineers, plus other responsibilities now vested in several different agencies. The Hoover Commission, may I remind you, was not concerned with governmental policies nor with political ideas. It did not say, for example, whether there should be a large-scale Federal system of Social Security; it merely said that *if* the American people, through their representatives in Congress, decide that Social Security is a proper function of the Federal Government, there is an efficient way to organize and administer such a program.

Here, then, is the essence of my message for you today: As engineers, study the Hoover Report as it applies to engineering problems; and go on from there As citizens, concern yourselves with all proposals for improving the efficiency of our government, to the end that we may withstand the buffets of more highly organized but fundamentally less sound governmental systems. As educators, accept your responsibility to open the eyes of the students, make them aware of their civic opportunities and their civic duties, encourage in them the questioning attitude, the non-acceptance of authority simply because it is authority.

For if we educators do our work well, there is yet hope that the greatest system of government yet devised by man—the democratic system—shall prevail and extend its influence wherever on this planet men want to claim their inalienable right to be men.

Development of the Teacher of Engineering

EDITOR: *A symposium on the development of engineering teachers was held at a meeting of the Illinois-Indiana Section at Purdue University, May 20, 1950. The following are statements prepared by those participating in the conference.*

Introduction

By A. A. POTTER
Dean of Engineering, Purdue University

That the engineering teacher is recognized, appreciated, and even honored by the engineering profession is evidenced by the fact that so many teachers have served and are serving as officers and on the governing boards of the major engineering societies. The ASME, since its foundation in 1880, has had out of a total of 68 presidents 13 who were teachers of engineering. The Lamme Medal and Westinghouse Awards for excellence in teaching and for the improvement of teaching are evidences of the interest of American industry in encouraging the engineering teacher. Of the 26 recipients of the Washington Award for conscientious service of engineers in the public interest, sponsored by the major professional engineering societies, six were teachers.

How teachers can be better prepared was the subject of a conference held in Chicago on December 8–10, 1949, under the joint sponsorship of the American Council on Education and the U. S. Office of Education. At this conference it was brought out that teachers must have attractive personalities, insight, sensitiveness, and perspective—they must be persons who have moral strength, a happy disposition, and a sense of humor, and who have an urge to be guides, philosophers, and friends of students, people who are scholars and who live up to high ethical standards. Above all, humanity is the distinguishing characteristic of a great teacher, who understands and loves his students as he understands and loves the subject he teaches—a person who has a quenchless desire to instruct, inspire, and aid his students.

Engineering colleges have in the past looked upon undergraduate instruction as their main function, and good teaching as a major responsibility. As research and graduate study in engineering grows, there has developed a fear in some quarters that a changed attitude with reference to good teaching may result; that is, there is a feeling on the part of many that pressure for graduate enrollment and for more research activity and publications may result in a condition now quite common in many of our university departments, where the teaching of undergraduates is left largely to unimaginative and unproductive older staff members or to graduate students.

The Philosophy of Engineering Education as it Applies to the Development of Teachers

By W. L. EVERITT
Dean of Engineering, University of Illinois

In all discussions on engineering education it is customary to state that we must stress fundamentals, that we must teach our students to think and that we must develop more than the technical side of the student. These are well accepted axioms but the real questions which need discussion are what *are* fundamentals, how can we create in the student confidence in his ability to learn, and what are the mechanisms for developing the broadened individual. Some people define fundamentals as those things they individually know best. Others consider fundamentals as merely those topics which come first in the logical development of a subject. We must go behind these simple concepts for a real insight into the matter and I can only approach it sketchily today.

The basic problem of all education is to teach the student how to make good decisions. You note that I say good and not correct decisions, because in most problems which are met in life there is not a unique answer and the information which is obtainable cannot be used to determine that one course is right and all others are wrong.

We should recognize that the education of an engineer or of any other professional man is a lifetime process; therefore, this problem of education is one of teamwork between the school, industry, and the individual. In our crowded curriculum the school must teach what it can do best and industry must be left to do what it can do best. This means that the university cannot devote much time to current practice, to how things are done in industry, but must lay a foundation on which the individual will continue to build throughout his career. It is obviously impossible to teach all that should be known and, therefore, alumni should not continue to request us to add to the curriculum specialized knowledge, just because they have found it useful, and which they think should have been taught to them in school.

Development of Teacher's Interest is Also Important

In considering the educational process we should recognize that the student is more important than the teacher, and the teacher is more important than the curriculum. In the ASEE and in other educational councils we have spent a great deal of time in discussing the curriculum, because that is something which can be analyzed on paper and upon which definite conclusions can be reached. We have considered the curriculum primarily from the standpoint of what the student should know. We have not given it much thought from the standpoint of the development of the teacher, which may in the end be even more important for a maximum benefit for the student. I am delighted that this year the emphasis of the ASEE has been placed upon the development of the teacher. I believe that this requires more than a one-year effort and should be continued. I hope that in the future we shall spend more time discussing problems of teaching as contrasted with details of subject matter. It is true that if we have good students even poor teachers may not hurt them too much, but unless we do provide mental development through contact with good teachers, universities can hardly justify their existence. A stimulating teacher can develop in the student the ability to tackle any subject, no matter how complex. This can be done through the medium of a wide variety of subject matter. On the

other hand, a poor teacher can make the most important subject uninspiring. Furthermore, the best rounded education can be produced by having teachers of all subjects who are themselves cultured and broadminded.

In discussing curricula a great deal of stress has been laid, in recent years, upon eliminating specialization at the undergraduate level. In much of this discussion the word "specialization" has been misused frequently almost to the same extent as the word Communism in political thought. If we consider our curriculum for the moment from the standpoint of the development of teachers, who in turn can do the best job for the student, I think it is undesirable to try and put students through a common mold, even in a given branch of engineering. It is necessary in a university to present a wide variety of subject matter in order to give the teachers an opportunity to develop and to make them feel that original ideas are worthwhile and acceptable. Before 1930 many electrical engineering curricula followed a common pattern in the mistaken belief that the fundamentals constituted those subjects which had always been accepted as the backbone of an electrical engineering curriculum. Those of us who were interested in developing the field of electronics were accused of specializing our students, although it is now accepted that the analysis of circuits involving the motion of electrons in space is as fundamental as an analysis involving only motion in wires. If a few schools had not allowed us to develop these areas through Communication options and elective courses, our own development would have been thwarted and a broader idea of what fundamentals are would not have been developed. It is difficult for a teacher to grow unless he is exploring new areas, and he will lack stimulus unless he is permitted in turn to convey his new found knowledge to his students. Furthermore, a certain amount of specialization is necessary in order to teach students how to solve harder problems requiring more background and integrating a number of fundamentals. It is broadness in thought rather than in subject matter that is the ultimate aim of many who are accused of introducing specialization in their teaching.

For fear I may be misinterpreted, I want to state plainly that I am still in favor of a broad base in social and humanistic subjects and in the basic sciences. In providing some electives or options in a technical curriculum we also open a stimulating area of competition between teachers. If the students are free to choose among several areas they show surprising good sense in going to the best teachers, and engineers certainly do not choose the easiest taskmasters. If the teaching in one area becomes dull or stodgy you will find a tendency for the students to elect an alternative option or course. This in turn will put the original group on their mettle to improve their teaching. Therefore I want to support the ideas of alternative programs not only in the division which occurs at the end of the freshman year, but also in the division that may be offered in a given branch of engineering in the junior or senior year.

The Scientist and the Engineer

In recent years there has been much confusion between the terms "scientist" and "engineer." If a distinction can be made I would say that the function of the scientist is primarily one of analysis. He seeks to know if a certain state of conditions exist, what would follow, what are the natural consequences. The primary problem of the engineer, on the other hand, is one of synthesis; he wishes to find out what conditions must be assembled in order to make a desired result follow. This means that the engineer must integrate from the world of knowledge all of the methods of attack which may be brought to bear on the problem. Synthesis is necessarily an art; it depends upon ingenuity and to a certain extent upon experience. The engineer must continually meet new situations. In fact, an en-

gineering education should unfit a man to do repetitive tasks. He must learn how to analyze a *problem* rather than confine himself to the straightforward relations of cause and effect. He must develop judgment. We recognize that all of this is not teachable at the college level; only a beginning can be made before the student is turned over to industry.

All of this indicates that one of the fundamental problems in engineering education is how to develop the ability to transfer ideas learned from the solution of one set of problems to an attack on a totally new set of problems. Psychologists insist that there is relatively little transfer of learning from one area to another. Rather than accept this conclusion on the basis of the teaching methods which they have studied, I think that a new area of research in teaching is indicated. This research should try to ascertain what are the principles which can develop an ability to make a transfer of learning. Such an ability is absolutely essential to the engineer. We have all observed individuals who have this ability to a high degree. We firmly believe that engineering education has in the past developed it to a definite extent. Undoubtedly improvement can be made in this area if we really understand the principles involved. I hope that psychologists and engineers can work together in the future in this important area of education.

The Part of Formal Courses in Education

By B. L. DOBBS

Director, Division of Education and Applied Psychology, Purdue University

It has been suggested that I discuss the part that formal courses dealing with the history and philosophy of education, the learning process, and teaching methods may play in the education of the engineering teacher. I am quite aware of the reservations that many people have concerning the effectiveness of any course which proposes to teach other people how to teach. There are some limitations which I think any of us who work in the field of education would freely recognize. Certainly the good teacher must have some concern for the individuals with whom he deals in the classroom and the conviction that what he teaches is important. This initial point of view, I believe, is fundamental. Also, it is certainly true that no individual becomes a good teacher except by the actual experience of teaching. However, it is reasonable to assume that if this experience in actual teaching is preceded or paralleled by some analysis and study of the principles and procedures involved that this experience in teaching can actually be much more profitable, and progress in the development of greater competence and skill be much more rapid. Good teachers, through experience, probably do learn the fundamental principles involved in the direction of the learning of other people, but this can be something of a trial and error and lengthy process. What may be gained by formal courses in Education is some ability to profit and develop through experience much more rapidly than would otherwise be possible.

There has developed a considerable body of observed experience and research in the social fields which deal with the problems of learning and human behavior. Granted that research in these fields is always complicated by the problems of controlling all but the experimental variable, nevertheless, there are some generally recognized principles which need to be understood if the teacher is to have any real insight into the teaching and learning process. Perhaps a few simple ex-

amples are appropriate to illustrate this point. For instance, an elementary but fundamental fact is that teaching is never anything but the direction of the learning of others. Students do not learn through the activity of the teacher by process of a passive absorption. Rather what the teacher can do and only can do is to set up situations in which the student is guided into some mental or physical activity of his own. Yet much teaching by inference ignores this fact.

The importance of considering and determining in a definite manner the objectives of a course is frequently not recognized by the beginning teacher: yet there are different types of objectives which call for very different kinds of learning activities in the classroom. For example, the mastery of a particular motor skill or the mastery of a given body of facts through memorization both call for some systematic type of drill activity and there are certain principles regarding the distribution of practice and review in order to secure retention and delayed recall. However, if the objective of the course is to develop the ability to solve problems and to do reflective thinking, drill procedure which is appropriate for the development of the more or less automatic skills will be largely ineffective.

One of the problems that faces every teacher is the problem of testing, evaluation, or measurement of the outcomes of instruction. There probably has been more systematic study of this aspect of the instructional program than of any other aspect. Many beginning teachers are quite unsophisticated about the procedures of measurement. Granted, that there are limitations to most types of measurements, there are a variety of devices which the beginning teachers should understand. Attaining a healthy distrust of some of the conventional means of testing is, in my judgment, not at all undesirable.

Personally, I have some degree of doubt of the extent to which a formal course in education can specify precise classroom procedures. These need to be adapted to the individual personality of the teacher and the type of teaching outcome desired. However, consideration of different types of classroom procedures can help broaden the beginning teacher's knowledge of available methods. Aid can be given in developing an understanding of the various types of audio-visual aids which may be used.

While I believe that the average beginning teacher is likely to be primarily concerned with the actual problems of instruction which he meets in the classroom and that this is the heart of any education program, I personally have a conviction that the good teacher must have, as well, a broad understanding of the role of education in our society, of the role of the professional school in our educational program, and some understanding of the organization and operation of the university in which he works. Therefore, while this may seem theoretical to the practical mind, I think it is very important that the teacher does develop a philosophy of education and the ability to see the part of his particular teaching field in the development of the individual and to understand the purposes of the university system of which he is a part. I know that the work which Dean Potter has done in his seminar on engineering education, which is the outgrowth of the philosophy and broad experience of a great teacher, can provide a fundamental orientation and stimulation to the beginning teacher. I would certainly hope that any work in formal courses in education would draw upon the resources of experience of staff in all department of the university and that any program of education of the prospective college teacher would have some time to deal with these broad problems of university and professional education.

These are obviously some very sketchy remarks. I do have a conviction that courses, which can be developed along with experience in teaching situations, can be useful in the development of teachers.

Interneship for Engineering Teachers

By F. L. WILKINSON, JR.
President, Rose Polytechnic Institute

I entered the teaching profession from industry approximately seventeen years ago, wholly unprepared for what I was to experience and completely aware of my inadequacy for the task. I approached my dean, a gentleman of over forty years' experience in teaching engineering, and asked for advice on "how to teach." I recall with what earnestness he said: "I do not know how to advise you. I think perhaps you would do well to look back over your college career and pick out the one among your instructors who inspired you the most, and emulate him," and he went on to say that he believed I should find that he was probably not one who had the greatest reputation as a scientist or engineer, but the one who stimulated my intellectual curiosity more than any other.

While I fully appreciate that I have never succeeded in my efforts at emulation, that advice has always been with me, and I soon came to the realization that I had not chosen one man to follow, but that in that first year I had built up a preceptor who was a synthesis of the good qualities of several under whom it had been my good fortune to sit as a student and as a practicing engineer. While I have never succeeded in my ambitions to become an outstanding teacher, this practice of evaluation and emulation I consider to be an excellent technique for one entering the teaching profession after a number of years of separation from the classroom.

We recruit our engineering teachers today from young men who have not had the advantage of a number of years in which to evaluate fully the effectiveness of those who taught them. They pass, for the most part, without pause from the role of student to that of teacher. The industrial employer would not think of giving to the recent graduate the responsibilities we in the engineering colleges have thrust upon him without a period of interneship or training in these responsibilities. Of course, the department heads and the senior professors are always at hand to assist in the evaluation of the tests and examinations he gives, in advice as to the degree of perfection to which he must hold his students, but all too frequently he faces his classes wholly unprepared for what he will meet in the classroom and laboratory.

As an administrator, constantly worried about financing the educational program of a small college, I am aware of the fact that what I have to propose for a solution of our dilemma is a drain on teaching budgets. It is, however, the development of a plan that we at Rose have undertaken as the result of experiences gained in the years immediately following the war when, like all of you, the administration was faced with the problem of meeting the temporary teaching demands of a swollen student body. Selected young men, recently graduated from our own institution and from others, with only the bachelor's degree, were employed as instructors. These young men were placed under the guidance of older members of the faculty, sat in their classes and observed the techniques of these men of greater experience, and concurrently taught sections in many of the courses they attended as observers. Employment was on a term to term basis and the turn-over was unusually high. On the other hand, there were a few whose interest in teaching became pronounced and whose abilities marked them as excellent prospects for the teaching profession. These were retained and they were gradually given greater responsibilities.

As the teaching loads in the various

departments fell off with the reduced enrollments, all but five of these young men were placed advantageously in industrial employment and the others continued as full-time instructors on the faculty.

Graduate Fellowship Plan

We recognize that their engineering education is incomplete, that a period of advanced study is now in order. The Institute, therefore, adopted a policy of providing graduate fellowships at other institutions for those whom we hope to retain. Two of these are pursuing advanced degrees under this plan at the present time. At least one will start his graduate work in September 1950, and the program will continue until all of those whom we hope to retain have received a minimum of a master's degree in engineering under a fellowship provided by the Institute.

While this plan developed under necessity, it has appealed to me from the aspects of interneship or practice teaching. It has been interesting to see that each of these young men has developed excellent teaching abilities through observation before fully completing his technical education. I believe that because there was a certain doubt of the thoroughness of their education on the part of the senior members of the faculty, they have received more attention from their seniors than if they had come to faculty fresh from graduate school. I firmly believe that upon their return to the faculty they will be even better teachers for, while they complete their technical education, they will be ever alert to evaluation of good teaching from those they sit under in graduate school.

Just as I am convinced that graduate school is of greater benefit to the practicing engineer if he has experienced several years of practice between his undergraduate and graduate years, I believe that better teachers of engineering will be developed through graduate work following teaching interneship. The important part of the program is the period immediately following his undergraduate years and the effort expended by the senior members of each department concerned in the period of interneship. In other words, good teachers must take as much interest in the interne as in the students they teach. I believe that the period of observation should be with the undergraduate teacher and not in graduate classes. If the period of observation is spent in the graduate classroom, the interne becomes a subject matter student and not a teaching observer.

Thus experience, born of necessity, leads me to believe that good teachers of engineering may be developed through teaching interneships between undergraduate and graduate years.

Orientation of Engineering Teachers

By J. T. RETTALIATA

Dean of Engineering, Illinois Institute of Technology

Many organizations devote considerable attention to the orientation of new members becoming associated with them. From experience it has been learned that properly acclimating and preparing the newcomer for the duties he is to perform is a sound procedure that pays dividends and promotes good public relations. Progressive industrial concerns have formal orientation training programs for graduate engineers entering their employ. Such programs acquaint the employe with some of the specialization peculiar to the particular company concerned; as it is recognized that sound engineering curricula are not intended to accomplish this end.

Educational institutions have not fol-

lowed the lead of industry and consequently, as a general practice, do not have in operation orientation procedures for teachers. In the opinion of many, such omission is not because the need is nonexistent as classroom instruction could undoubtedly be improved in many respects. The formal undergraduate and graduate education of the prospective engineering teacher contains little to make him adept in future pedagogical pursuits. In fact, there are some who claim that emphasis on research has an aggravating influence on the attainment of good teachers. The graduate engineer entering industry probably can apply his college work as directly to his job as can the engineering teacher, yet industry has seen the necessity for introducing orientation programs. It is reasonable to expect that they could also serve a useful purpose in academic institutions.

In the educationally critical period immediately following World War II, when teachers were difficult to obtain but students were not, in order to accommodate the increased enrollment it was necessary to resort to some practices which did not produce optimum teaching results. In some instances a larger than desirable portion of graduate students was used for classroom instruction, and also there was a tendency to retain staff members beyond retirement age. Even though the cause for this situation is passing, some faculty members believe the condition is being perpetuated by, in their opinion, an excessive accentuation of publications and research at the expense of recognition of the good undergraduate teacher.

It is probably significant that faculty rating by the students increased in popularity in the post-war period and, while many question the competence of the student to comment on teaching methods, such ratings will conceivably be used to a greater extent in the future. In order to minimize the need for this sort of student appraisal, improved teaching accomplished through orientation programs would be worthwhile.

Characteristics of Good Teachers

It is commonly accepted that one of the most desirable qualifications of a teacher is a thorough knowledge of the subject matter. All too frequently there is the implication that such knowledge infers the guarantee of a good teacher. Refutations of this, however, are sufficiently numerous to establish the premise that mere possession of understanding is not automatically accompanied by the ability to impart it to others. It is this transmission of the understanding of the subject matter from teacher to student that must be accomplished. A good teacher possesses a high "transmission efficiency" in addition to mastery of his subject. As far as the student is concerned, the teacher's intellectual command of his field may be nullified by poor transmission tactics. The product of both factors should be high in order to accomplish the desired result.

The principal intent of an orientation program would be to develop the transmission factor in all of its aspects, as it will be assumed that the candidate has previously given evidence of his having an adequate knowledge of the field in which he is engaged. Occasionally one sees listed the desirable attributes of a good teacher. Such enumerations usually include so many virtues that it is questionable whether a single individual possesses a large combination of them. Since many of these characteristics depend upon the basic nature of the individual it would not appear that an orientation program should embrace development of such items to any large degree, but rather be aimed at improving pedagogical skills as its primary objective.

Importance of Orientation Programs

To be successful it is believed that an orientation program should be conducted on a scheduled basis, meeting regularly throughout the academic year. At the writer's institution such a program was arranged with weekly meetings. At each session the speaker was a staff member recognized as an authority in the par-

ticular subject under discussion at the time. Best results can be obtained if the meetings are conducted in round-table fashion so that adequate opportunity for discussion can exist.

Since the orientation program is intended to acquaint the inexperienced teacher with the principles of effective teaching, the topics to be covered should include background material as well as instructional techniques. A logical introduction would explain the preparation of departmental curricula, courses, course outlines, and individual lesson plans, emphasizing the educational objectives to be attained.

The proper procedure for conducting a class session could next be considered. The presentation should include means for arousing student interest by explaining the purpose of the course, how it is integrated into the complete program, and its possible application in future jobs. The importance of a good personal appearance should be stressed. The instructor should give evidence of being self-confident and in command of the classroom situation. Such command is best achieved by thorough knowledge of the subject so as to eliminate the necessity of evasiveness or bluffing when replying to questions from students. Annoying mannerisms of person or speech involving disturbing gestures should be controlled.

Familiarity with the salient features of accepted public speaking procedures would benefit the new instructor. Sincerity and enthusiasm will animate the presentation and promote interest on the part of the student. Formal lecturing is not necessary and in the majority of cases probably undesirable. Rather a better method would involve participation by the student, as such direct association with the class session encourages more active interest.

The application of principles learned in the lecture course can best be made in the laboratory. The new instructor should recognize the basic importance of laboratory courses and strive to conduct them in a manner conducive to the attainment of desired results. Some students understand theory only when they see it demonstrated in the laboratory. Many students enter the laboratory without adequate preparation so a good plan would be for the instructor to brief the students regarding the purpose of the experiment to be performed, so that it can be conducted more intelligently and correct conclusions obtained. Laboratory groups should not be too large if participation of all students is to be realized. The students should know that well-prepared laboratory reports, although not necessarily lengthy ones, with sound conclusions are expected. An examination in the laboratory course is desirable to determine individual student performance. It is the responsibility of the instructor to see to it that proper safety precautions are adhered to by the students in the laboratory. For best coordination the same instructor should teach both the lecture and laboratory courses in a given subject.

Better Use of Instructional Aids

The new teacher should be informed of the proper use of instructional aids. It should be emphasized that such aids are for the purpose of enhancing the teaching process and are not intended as a substitute for the instructor. Consequently, he should not regard them as a means of reducing the expenditure of effort on his part. On the contrary the proper use of such aids requires intelligent preparation in order to accomplish worthwhile results. The majority of instructional aids are visual, and the most common and useful one is the blackboard. Notwithstanding its many years of existence, the blackboard is still misused by many teachers. Some instructors retain a fondness for directing their remarks to it instead of to the students, and some have a tendency to conceal what they have written by interposing themselves between the students and the part of the board being used. These are common and obvious failings, but the new instructor must be made cognizant of them so as to be on the alert and not lapse into such

practices. At all times, extraneous material not pertinent to the subject under discussion should be erased so as to avoid distraction on the part of the students.

Textbooks, notes, instructions, etc., may also be considered as instructional aids and knowledge of their proper use should be acquired. Other aids would include models, charts, lantern slides, and motion pictures. Each has its place and when used correctly much benefit can result by the additional clarification which would otherwise be difficult to obtain. It should also be remembered that successful demonstrations with instructional aids are not automatic and adequate prior preparation on the part of the instructor is essential.

It is important that the inexperienced teacher learn the proper manner in which to measure the progress of the student. The usual device is the written test. Occasionally the young instructor believes that the adoption of a tough attitude impresses the students with his brilliance and mastery of the subject. In executing this belief he has a tendency to give difficult and unreasonable tests. This may establish his position of authority to his satisfaction, but such procedure is not in keeping with the intended philosophy of constructive measurement. It should be pointed out that tests not only establish a grade in the course, but also are a means of emphasizing the important and essential parts of a course. The results of a test furnish information to both instructor and student. The latter learns of the areas wherein he may be weak, and the instructor whether his methods are effective as evidenced by the performance of the class as a whole. Much thought should be devoted to the preparation of tests to assure their being representative of the material covered in class. Tests should be graded and returned promptly so that the student knows of his performance without delay.

Progress may also be observed by having the students go to the blackboard during the class session. Such participation, involving the direct application of principles while under supervision, is an excellent means of assuring the instructor that the student is not merely taking notes throughout the semester without appreciating their significance through utilization.

In making homework assignments the new instructor should appreciate that the outside time of the student is limited and must also be used in preparation of other courses. Consequently, such assignments should not require an unreasonable amount of time. Some determination of progress can be obtained by having the students explain the homework problems at the blackboard, although such a presentation may not necessarily be the result of independent effort.

Role of the Administration

Attending all of the sessions where the above items are discussed is only a partial step in the proper orientation of the new instructor. He must diligently put into practice the principles learned. If possible he should work under an experienced teacher and observe the application of correct procedures in actual operation. The department head should offer continual counsel and guidance while the newcomer is acquiring experience.

It should be recognized that the college administration has a definite responsibility in the attainment of a successful orientation program. Teaching loads should not be excessive if the new teacher is to have sufficient time to devote to his improvement Class sizes should not be too large. Adequate facilities, space and equipment should be provided. Student graders should be made available to relieve the instructor of routine homework grading.

Obviously, the foregoing brief remarks are not intended as an exhaustive treatment of the matter of an orientation program for engineering teachers. Most of the suggestions presented are not novel, but rather have long been recognized as desirable practices for teachers to follow. Undoubtedly there is room for improvement in engineering teaching, and it is believed much progress can be accomplished through well-conducted orientation programs.

Lamme Award—1950—Fred B. Seely

FRED B SEELY

To FRED B. SEELY *for his excellence as a teacher, his sympathetic understanding of his students, his clearness in presenting subject matter, both in class and by written text, his combination of research and teaching to make him a well balanced leader of his staff: for his contribution as a citizen of his community, his devotion to his profession, his contributions to technical societies to which he has devoted his energies; and for the high esteem in which he is held by his colleagues, we award this the twenty third Lamme Medal.*

FRED B. SEELY, the twenty-third Lamme medalist of the American Society for Engineering Education, has made lasting contributions to the enrichment of engineering education through his stimulating teaching and research; through his writings that have added to the permanent literature of engineering; through his administrative leadership in developing the creative talents of the teaching staff; and through his understanding of the importance of the proper balance in the relationship between engineering education and the practice of engineering.

Professor Seely was born in Chester, New York, April 29, 1884. After graduation from Worcester Polytechnic Institute in 1907 with a B.S. degree in mechanical engineering, he spent a short time in industry. The urge, however, to explore and clarify ideas and concepts in engineering naturally led him into the field of university teaching and research. He joined the staff of the Department of Theoretical and Appied Mechanics, University of Illinois, in 1909, received the M.S. degree in 1915 and was appointed to a full professorship in 1921. He became head of the department in 1934—the position he still holds.

Parallel with his teaching he carried on research in materials, mechanics of materials and hydraulics, and published numerous technical papers. A considerable number of these papers were the outgrowth of research carried on in close cooperation with students; and the research projects were started primarily as a means of developing the student.

His strong interest in effective teaching also led him to the writing of textbooks. He entered his life work at a time when the topics of mechanics and materials had burst the bonds of the earlier formalism and there had already appeared a broader perspective of the subject of mechanics involving an engineering as well as a scientific or theoretical viewpoint. This emerging scientific-engineering way of thinking permeated his textbooks: "Analytical Mechanics for Engineers" (with N. E. Ensign). "Resistance of Materials" and "Advanced Mechanics of Materials." These books were superior in character; they coordinated and integrated the subject matter into that unified whole which was needed especially by the beginning engineer. The significant effect which they have exerted on engineering education for the past quarter of a century is evidenced by the American Society of Mechanical Engineers' award to him in 1949 of the Worcester Reed Warner Medal for his "outstanding contribution to permanent engineering literature."

Through his enthusiasm and administrative leadership as Head of the Department of Theoretical and Applied Mechanics he has been very successful in promoting an educational program for developing the creative talents of the teaching staff. He has done much to establish faith in the dictum that one effective way to develop the alert teacher needed for instruction on the University level for both undergraduate and graduate instruction is for the instructor to combine teaching and research in such a way that each is made better by the other.

As chairman, for a score of years, of a committee on Engineering College Policy and Development he exerted a wholesome influence on engineering educational policies at the University of Illinois, by urging re-examination of methods and objectives and by encouraging reasonable

experimentation aimed at the improvement of classroom and laboratory instruction.

His breadth of interest and active mind carried him beyond the academic atmosphere of the classroom and laboratory. Always interested in community affairs he has served in various capacities; as a city alderman; as Vice President of a Savings and Loan Association and as a member of several civic boards. He is an active member of the American Society of Mechanical Engineers, the American Society for Testing Materials, the American Society for Engineering Education, of which he was a member of the Council in 1937–40, and the Engineers Club of Chicago. He is also a member of the honorary scholastic societies of Tau Beta Pi, Sigma Xi, and Phi Kappa Phi.

College Notes

The appointment of Ashley S. Campbell, of the Division of Engineering Sciences, Harvard University, as Dean of the College of Technology at the **University of Maine**, was announced by Dr. Arthur A. Hauck, president of the university. Dr. Campbell succeeds Dean Paul Cloke who retired in June after serving 24 years as head of the college. Dr. Campbell was an instructor in the Harvard Graduate School of Engineering in 1947–48 and assistant dean of the school in 1948–49. Since that time he has been assistant professor of engineering science with primary responsibility for developing the Harvard laboratory in mechanical engineering. Dean Cloke has devoted almost a quarter of a century to his work at the University of Maine, and has worked devotedly and effectively in carrying forward the high standards of the College of Technology.

John Ray Dunning, professor of Physics, scientific director of Columbia's new cyclotron, and a pioneer in atomic research, has been appointed dean of the School of Engineering at **Columbia University**. Dr. Dunning succeeds Dean James K. Finch, who will retire June 30.

Robert Edward Stiemke, professor of sanitary engineering at the Pennsylvania State College, has been appointed director of the School of Civil Engineering at the **Georgia Institute of Technology.**

A cooperative program enabling engineering students to obtain a broad general education before concentrating on a chosen special field of science or technology has been effected by **Rensselaer Polytechnic Institute** and **Franklin and Marshall College.** The agreement is similar to those Rensselaer has made recently with three other centers of the liberal arts—Washington and Lee University, Trinity College and St. Lawrence University. Under the plan students may elect to complete three years of the regular liberal arts program at Franklin and Marshall, with emphasis on the basic sciences and mathematics, before entering on two years of specialized study in one of Rensselaer's major departments.

George Westinghouse Award—1950—
Rolf Eliassen

To Rolf Eliassen *for outstanding and devoted teaching in Sanitary Engineering; for warm and friendly guidance of his students, characterized by a deep personal interest in their careers; for unusual laboratory development and other visual aids to better teaching; for stimulating short courses for practicing engineers and technicians; and for many research contributions of a high order, this fifth George Westinghouse Award is granted.*

The fifth recipient of the George Westinghouse Award has achieved national renown for his distinguished contributions as an engineering consultant to the government, as an inspiring and enthusiastic teacher, and as director of the Sanitary Engineering Program in one of America's foremost engineering colleges.

Rolf Eliassen, Professor of Sanitary Engineering in the Department of Civil and Sanitary Engineering at the Massachusetts Institute of Technology, was born in Brooklyn, New York, on February 22, 1911. He is a graduate of M.I.T. in the class of 1932, where he received a B.S. degree in civil and sanitary engineering. He holds M.S. and Sc.D. degrees from the Institute, granted in 1933 and 1935, respectively.

Following the completion of his education at M.I.T., Dr Eliassen served with two consulting engineering firms before going to the Illinois Institute of Technology as Assistant Professor of Sanitary Engineering in 1939. One year later he became Associate Professor of Sanitary Engineering and Director of the Sanitary Engineering Research Laboratory of New York University, to which post he returned as full Professor in 1946.

At New York University, Professor Eliassen was in charge of the teaching and research program in sanitary and public health engineering with special emphasis on the purification of water and sewage From 1940–42 he served as consultant to the National Resources Planning Board on the quantity and quality of water available for defense industries in the middle Atlantic states; in the summer of 1941, in association with Parsons, Klapp, Brinckerhoff and Douglas, Dr. Eliassen supervised the design of water and sewage systems for Army posts in the Caribbean Defense Command.

During World War II, Dr. Eliassen was in charge of the sanitary engineering division of the Second and later of the Ninth Service Commands, as Captain, Major, and Lieutenant Colonel in the Corps of Engineers. For four months he was assigned to the Biarritz American University at Biarritz, France, as head of the Department of Civil Engineering.

At M.I.T. since 1949, Professor Eliassen has been in charge of an expanding research program in water purification and waste disposal problems. As director of the Institute's sanitary engineering curriculum, Professor Eliassen is in charge of the graduate course as well as extensive undergraduate work in the field given within the civil engineering course.

Widely known for consulting work and publications in the field of sanitary engineering, Dr. Eliassen is a member of the American Water Works Association, the American Public Health Association, and the American Society of Civil Engineers. From 1946 to 1948, he served as Chairman of the ASCE Committee on Refuse Collection and Disposal, and in 1949 as Chairman of the Committee on Corrosion Control.

James H. McGraw Award—1950—
Harry Parker Hammond

To HARRY PARKER HAMMOND *for his outstanding contributions to technical institute education; for his stimulating leadership in the development of technical institute training facilities, particularly in the State of Pennsylvania; for his tireless efforts in establishing a nationally recognized technical institute accrediting agency under the auspices of the Engineers' Council for Professional Development; for his many articles and public appearances on the subject of technical institute education; for his keen analyses of the relationships between engineering education, the engineering profession, and technical institute training; for his guiding influence in the growth and development of the Technical Institute Division of the American Society for Engineering Education.*

Harry Parker Hammond, Dean of the School of Engineering, The Pennsylvania State College, received the degree of Bachelor of Science in Civil Engineering in 1909 from the University of Pennsylvania. In 1915 he received the degree of Civil Engineer from the same institution. The honorary degree of Doctor of Engineering was awarded Dean Hammond in 1931 by the Case School of Applied Science, and in 1943 the University of Vermont made him a Doctor of Laws.

He served as an instructor in civil engineering during two years at the University of Pennsylvania and during one year at Lehigh University. In 1912, he became Assistant Professor of Civil Engineering at the Polytechnic Institute of Brooklyn, was appointed Professor of Civil Engineering and Head of the Department in 1927, and remained in that position until 1937 when he was appointed Dean of the School of Engineering of The Pennsylvania State College. Under Dean Hammond's leadership at Pennsylvania State College, there has developed through the Extension Division a broad and effective program of technical education, including the establishment of seven day and ten evening technical institutes.

Dean Hammond's great interest in engineering education and his influence upon it have been manifested most directly by the exceptional contributions he has made to the American Society for Engineering Education over a period of twenty-five years. He served that Society as Vice President in 1934–35 and as President in 1936–37. He served as chairman of some of its most important committees, was a member of the Council from 1927 to 1930, and was an ex-officio member of the Council as Past President. In 1945, Dean Hammond received the Lamme Award, generally recognized as the most distinguished mark in engineering education.

In 1943, Dean Hammond accepted the chairmanship of a special ECPD committee created to study the technical institute accrediting problem. The report of his investigating group submitted to the Committee on Engineering Schools in April, 1944, led to the creating of an active accrediting committee to evaluate programs of technical institute type. Dean Hammond accepted the Chairmanship of this Committee and has provided active leadership in it since that time.

Throughout his years of service in these activities and offices he has been one of the few outstanding engineering educators who has fully recognized the relationship of technical institute instruction to professional engineering education. He has served as an influential technical institute spokesman among engineering educators principally concerned with college and university instruction. He has done much to give them an understanding of the place the graduate of the technical institute can fill in engineering and industry.

Report of the Engineering College Administrative Council

In November 1949, the Administrative Council, in cooperation with the Engineering College Research Council and the Land-Grant College Association, held a meeting on the subject "Atomic Energy Developments Present Engineering Education With New Problems." Five papers were presented at the meeting. Chairman Terman at the end of the meeting gave a most effective summary, and among other things pointed out that from the discussion it was evident: (1) atomic developments are going to affect civil, electrical, mechanical, chemical, and metallurgical engineers, (2) no engineers will be able to ignore atomic developments in the future; (3) it appears worthwhile to re-examine the fundamental physics training now required of all engineers to see whether it contains an adequate introduction to such matters as radio activity and atomic structure.

After several years of discussion and much planning this year, the ECAC is trying out the plan of holding one closed session open only to accredited engineering institutions and at which matters of primary concern to administrative officers will be discussed. In order to insure that each accredited institution would be represented, the Executive Committee instructed that a letter be written to presidents of member institutions asking that they officially designate a representative to this closed meeting. Some 143 institutions were thus notified.

At the March meeting of the Executive Committee, it was decided that the ECAC would make its "project of the year" an attempt to determine through a sampling procedure just what actually is happening to our college graduates from the point of view of employment. The need for such a survey is brought out by the fact that last year many more engineers found employment than had been predicted.

The plan is to enlist the cooperation of every engineering school in circularizing its 1950 engineering graduates with a questionnaire which would indicate the type of employment in which the graduate is employed. An anonymous questionnaire would be sent to one-half of all engineering graduates. In certain schools only, the other half of the students would be sent the same questionnaire and a careful follow-up would be made to be certain that all of these questionnaires had been received. The latter step would provide a means of interpreting the results of the survey as a whole.

The following is a list of new committee chairmen:

Manpower—G. D. Lobingier
Secondary Schools—W. S. Evans
Military Affairs—D. B. Prentice
Selection & Guidance—H. R. Beatty
International Relations—W. R. Woolrich

The following persons have been added to the Executive Committee:

J. H. Davis
T. Keith Glennan
J. F. Downie-Smith
H. E. Wessman

The Administrative Council is planning a meeting dealing with the general subject of emergency college educational programs, to be held at the conclusion of the Land-Grant College Association meeting in Washington, D. C., November 13–17, 1950.

Respectfully submitted,

F. E. Terman, *Vice President ASEE and Chairman ECAC*
J. H. Lampe, *Secretary ECAC*

Report of the Engineering College Research Council, 1949-1950

It is our pleasure to present a new brochure, "Research is Learning," created as a definitive statement, with case-history examples, of the purposes of engineering research in our member institutions. "Research is Learning" emphasizes the position of research as a part of education in engineering schools. To widen the understanding of that position, and to increase the effectiveness of research as an educational tool, are the primary tasks of the Engineering College Research Council.

We are not a research management authority. While our purposes encompass discussion of research and patent administration from the point of view of efficiency and effectiveness, we must not forget—just as any individual research director must never forget—that administration is a means, not an end. We are not organized to promote research as a business for colleges and universities. Educational institutions must chart their courses with increasing care in order to avoid the hazards of competing with taxed, profit-making enterprises. Our aim is to attract that type of research which properly contributes to the educational environment—and to show that we can in reality work with commercial research organizations in the discharge of our responsibilities, not compete with them.

When the Engineering College Research Association, our predecessor organization, was formed, one of its goals was to represent *all* universities and so to spread the responsibilities and advantages of educational research to all engineering schools, large and small, throughout the country. Each member institution, irrespective of its size, enjoys equal participation in the Research Council. We are certain that it is important to have the advantages of active research work felt on every campus. Broad distribution of research insures a larger supply of well-trained engineers, and it helps to spread the burden of responsibility for fundamental studies so that no one institution need accept so much work that research becomes a responsibility threatening to overshadow the educational purpose.

The creation of the National Science Foundation this spring marked an event in behalf of which the Research Council and the entire Society have taken an active role since the end of World War II. The Foundation will go far to assure permanent interest in and support for the type of research which is of greatest value in educational institutions and which we are convinced is of fundamental value to the nation. Cooperation with the National Science Foundation should be a major responsibility of the Research Council.

The increasing urgency of the "cold war" may give us additional responsibilities in the months immediately ahead. In times of peace we in engineering schools are privileged to center our efforts exclusively on those researches which seem to best fulfill our purposes and goals. But, in the national interest, we may soon be obligated to undertake projects with very specific military purposes and, in consequence, the necessity of security restrictions. During World War II we learned the fallacy of devoting our full energies to work of this character, at the expense of fundamental research and education. Even in wartime, fundamental research and education must continue without secrecy restrictions.

It is fitting to summarize details of the Research Council's 1949–1950 fiscal year, and to review our financial position.

We concluded our largest publishing venture early in the year with distribution of 2000 copies—the full printing—of the 1949 *Review of Current Research and Directory of Member Institutions.* In addition to cash sales, which resulted in an income of more that $800, we invited member institutions to pass complimentary copies to those of their associates and sponsors concerned in engineering research, and our committees achieved a substantial distribution to government and industrial officials. Its enthusiastic reception by recipients and by reviewers in the engineering journals was most heartening.

A new Committee on Relations with Industrial Research Agencies has been set up during the course of the year, under the direction of Harold K. Work, Director of Engineering Research at New York University. Evidence of this Committee's activity is the session on "Industrial Research in the Pacific Northwest," at the 1950 Annual Meeting. Our other Committees, on Relations with Military and Federal (Non-Military) Research Agencies, have continued to serve us effectively.

The Research Council's fall program, in Kansas City, Missouri, October 28, 1949, was designed to be of special interest to smaller institutions. The short papers presented were collected into an inexpensive leaflet on "Research Policies and Pitfalls," which enjoyed such a wide acceptance that our supply was promptly exhausted. The meeting was reviewed prominently in several journals. Late in the winter we completed work on the largest *Proceedings* ever printed by the Research Council, covering the sessions at Rensselaer Polytechnic Institute.

One of the most promising developments of the year is growing out of a meeting of research directors in colleges in the Pacific Northwest. They have formed an informal organization which will probably become the first regional branch of the Research Council. The administrative details of this new type of activity are now being worked out by our Executive Committee.

Sales of ECRC publications have enabled us to maintain a surplus of income over expenditures throughout the year, despite the heavier-than-usual expenses of the 1949 *Proceedings.* But many of the costs of the publications we have sold this year were paid for out of last year's deficit. Our financial position does not encourage many new activities, even if they are carried out in the most economical fashion possible, and the question of how to make most effective use of our resources is a serious one before the Executive Committee.

In the Annual Election for new officers of the Research Council, our members have chosen the following:

Chairman (two years)—Dr. Gerald A. Rosselot, Director of the Engineering Experiment Station, Georgia Institute of Technology.

Vice-Chairman (two years)—Professor A. G. Conrad, Chairman of the Department of Electrical Engineering, Yale University.

Directors (three years)—Dr. Ralph A. Morgen, Director of the Engineering and Industrial Experiment Station, University of Florida; and Dr. Kurt F. Wendt, Associate Director of the Engineering Experiment Station, University of Wisconsin.

Director (one year, to fill the unexpired term of Dr. Rosselot)—Dr. Eric A. Walker, Director of the Ordnance Research Laboratory and Head of the Department of Electrical Engineering, The Pennsylvania State College.

F. M. Dawson, *Vice President ASEE, and Chairman ECRC.*

Report of the Vice-President in Charge of General and Regional Activities

Regional Activities

Section and Branch Affiliations

The Upper New York Section has inquired about the possibility of certain Canadian schools affiliating with that Section. The Section Chairman was advised of previous correspondence with the Chairman of the Committee on Applied Science and Engineering Education of the National Conference of Canadian Universities, and it was suggested that the proposed affiliation be cleared with that Conference prior to official presentation to the ASEE General Council, which under the Constitution prescribes the territorial limits of Sections.

As this report is written, active steps are being taken looking to the establishment of Branches of ASEE at the University of Tennessee and at Texas A. & M. College.

Section Meetings

Information at hand indicates that of the 16 Sections of ASEE, 12 have had one meeting during the year, 1 has held two meetings, and 1 has held three (two of which were evening meetings). Nine of the 14 day meetings have had one-day programs, four have had two-day programs, and one program has covered three days. It is believed that every Section meeting has been attended by at least one national officer. Your Vice-President has attended four meetings.

Section programs have included such topics or program themes as Testing and Guidance, Industry-College Relationships, University Cooperation with Government, Career Opportunities in Government for Engineers and Scientists, Objectives in Engineering Education, Improvement of Engineering Teaching, Examinations and What They Measure, Speaking Techniques, in addition to group meetings by major curricula or by general subjects.

A few reports of Section and Branch meetings have been received but have not contained enough items of special significance to warrant the proposed clearing house bulletin. This subject will be on the agenda for the June meeting of the Committee on Sections.

Study of Functions of General Council

It was suggested last fall that the Sections and Branches study the functions and operations of the General Council, in an effort to find means for improving its general effectiveness and its service to the individual members. One Section has had a committee studying this matter during the year. The committee has submitted a report which suggests no changes in the operations of the General Council, but recommends several changes in Section procedures, which will be studied by the incoming Section officers.

Manual for Section Officers

An outline for the proposed Manual for Section Officers was approved by the Committee on Sections last October, and the Chairman of the Committee was authorized to appoint subcommittees to prepare various portions of the Manual. A considerable volume of material was collected from Section officers, and distributed to the subcommittee chairmen for study. As this report is written, all subcommittees have reported and a preliminary draft of the Manual has been sent to all members of the Committee on Sections for criticisms.

General Activities

General Society activities of your Vice-President during the year have included the following:

Engineering Enrollments and Degrees

Under the terms of its agreement with ASEE, the U. S. Office of Education gathered and tabulated data on engineering enrollments and degrees and turned over the tabulations to the Secretary of ASEE. Reports were received from all but one of the ECPD accredited institutions and from 39 institutions listed in the Office of Education directory but not accredited by ECPD.

The Office of Education on March 20 issued its Circular no. 266, "Engineering Enrollments and Degrees, 1949," by Messrs. Story and Armsby, which reported:

(a) Total enrollments and degrees at the bachelor's, master's and doctor's levels for all institutions, with the ECPD accredited ones starred, and
(b) Similar data for each curriculum, with ECPD accredited curricula starred.

This report does not duplicate the ASEE report, but makes available for the first time data which should be of considerable value and for which the Office of Education has had many calls.

Society Representation

At the request of President Saville, your Vice-President represented the Society at a conference held by the U. S. State Department on February 2 and 3, 1950, for a discussion of the problems incident to the possible development of President Truman's Point IV program. Reports were rendered to President Saville and to the Executive Board on this meeting, and liaison is being continued with the State Department as to possible contributions this Society can make to the Point IV program, when and if established.

At the suggestion of President Saville, your Vice-President represented the Society at the annual meeting of the National Committee for Traffic Safety, which was held in Washington on March 9, 1950.

Preliminary conversations were held with officials of the Atomic Energy Commission, leading up to the appointment by President Saville of a Steering Committee on Cooperation with the Atomic Energy Commission to explore the subject of regional conferences between engineering colleges and Atomic Energy Commission officials. Liaison with the Atomic Energy Commission is being continued, and assistance is being given in arranging the details of a preliminary conference of the Steering Committee with Atomic Energy Commission officials, to be held in Washington on June 2 and 3, at which your Vice-President will preside.

"Engineers—Too Many or Too Few"

A news release, which had the approval of five members of the ASEE Manpower Committee who live in and near Washington, and of the Chairman of the Manpower Committee, was approved by the Executive Board on March 1, 1950, and released by Secretary Bronwell on March 15. A slightly modified version of this statement was published in an issue of *Higher Education*.

A joint enterprise was worked out with the Office of Education whereby reprints of this article accompanied by a letter over President Saville's signature were prepared at Society expense and about 5600 copies were mailed at Office of Education expense to the following groups:

1. All private high schools for boys in the United States.
2. All public, regular, senior, and senior-junior high schools for white students which last year enrolled 300 or more students.
3. All Chief State School Officers.
4. All engineering deans.

5. About 200 educational journals, the Associated Press, and the United Press.
6. All members of the ASEE Executive Board.

One thousand copies were sent to Secretary Bronwell for distribution to engineering colleges. As soon as this reprint reached the engineering deans, both Secretary Bronwell and your Vice-President began to receive letters and telegrams from Deans asking for large numbers of copies of the reprint. In view of this demand, a second printing of 5000 copies, and a third printing of 8000 copies, were made and sent to Secretary Bronwel for sale to engineering deans at cost (approximately 1½ cents per copy).

It is evident that the article is attracting considerable attention, and it is hoped that it may help to offset the unfavorable impression created, not so much by the Bureau of Labor Statistics report as by some of the press releases about that report.

Service on ASEE Committees

Your Vice-President is continuing his membership of the Society's Committee on Secondary Schools, on the Cooperative Engineering Education Division's Committee on Relations With Federal Agencies, and on the Society's Manpower Committee. In the latter capacity, he is preparing three reports for presentation at the June meeting; namely, an estimate of the supply of engineers for the near future, a discussion of methods of predicting future engineering enrollments, and a discussion of the prospective demand for engineering teachers.

Respectfully submitted,

HENRY H. ARMSBY, *Vice-President in charge of General and Regional Activities, and Associate Chief for Engineering Education, U. S. Office of Education*

College Notes

A curriculum in nautical engineering, to provide professional training for graduate engineers and scientists, has been established jointly by the Graduate School of **Stevens Institute of Technology** and **Webb Institute of Naval Architecture.**

A new curriculum for combined liberal arts-engineering education has been announced by six Middle Western colleges. Participating in the new plan are Coe College, DePauw University, Marietta College, Oberlin College, Ohio Wesleyan University, and **Case Institute of Technology.** The plan, designated as the "Binary Curriculum," involves three years of study at one of the liberal arts colleges and two years and a summer of work at Case. Upon completion of the graduation requirements of each institution, the student will receive the bachelor of arts degree from the liberal arts college at which he has taken his first three years of work and the bachelor of science degree in a specialized engineering field from Case.

Maurice Nelles, engineering and research manager for the Allen Hancock Foundation, University of Southern California, has been named professor of engineering research and director of the Engineering Experiment Station at the **Pennsylvania State College.**

Report of the Vice-President for Instructional Divisions

In July, following the Annual Meeting, a letter was sent to the various Division and Committee Chairmen enclosing a list of approved budgets and calling attention to the necessity for early planning of the program for the 1950 meeting at Seattle. In order to have the program printed and reach the membership well before the Annual Meeting, it is necessary to have the program in the office of the Secretary by February 1st on account of the delay in printing and mailing that is necessary under present conditions. The cooperation received was gratifying and greatly appreciated by Secretary Bronwell and your Vice-President.

Attention of the various chairmen was called to the reservation of a page in the Journal which any Division or Committee could use to convey any message desired to the general membership. Some Divisions took advantage of this page.

Division By-Laws

The chairmen were asked to file with the Secretary copies of any Division By-Laws which might be in effect. Six or seven Divisions have filed By-Laws; many of the others apparently do not have them. While a Division may be operating without a set of standard By-Laws, circumstances sometimes arise when they are necessary.

Conference for Old and New Division Chairmen

Last year, President Saville, then Vice-President for Divisions and Committees, called the first meeting of old and new chairmen at the Annual Meeting in Troy. Although called on short notice, this conference was so interesting and worthy while that it has been placed on the regular program.

Support of Young Engineering Teachers Committee

This office was authorized by the Executive Committee to write to the various Deans of Engineering, calling attention to the conference for young engineering teachers to be held at Seattle and suggest that the various schools might wish to defray a part or all of the expenses in attending the Annual Meeting for some young instructor on the engineering staff. The importance of encouraging the activity of young staff members in the affairs of this Society cannot be over-emphasized. The Society can do much for these young men and these young men can likewise do much for the Society. Several letters were received from deans who stated that they were glad to accept this suggestion.

Division Publications

A number of Divisions are publishing excellent printed or mimeographed bulletins of special interest to Division members. These bulletins often contain papers presented at meetings of the Society which are of special interest to members of the particular Division. Some of these publications are issued regularly, others at unspecified intervals. On account of the cost of publication and mailing, the Journal cannot be enlarged to carry many papers of special interest which would be read by a relatively small portion of the Society membership. It is believed that these special publications are very appropriate and serve an important need. They are self supporting,

sometimes by subscription from the membership of the Division and sometimes by solicitation of commercial advertising.

Summer Schools

Three summer schools have been approved by the Executive Committee; one by the Humanities Division is being held here in Seattle immediately following this Annual Meeting. Another by the Mechanics Division to be held at Iowa State College in September of this year. A third was sponsored by the North Midwest Section and was held at the University of Minnesota. This summer school was devoted to an analysis of good teaching, a discussion of teaching methods, evaluation methods, visual aids, etc., from an all-engineering school standpoint. It was first suggested in a Mechanical Engineering Division meeting at the North Midwest Section Conference held at the University of Iowa last fall. It was taken up and sponsored by the young men of the North Midwest Section. The General Sessions were open to all teachers of engineering but departmental conferences were held following the general meeting. One hundred and sixty young engineering teachers attended this conference although it was held during the school year and not in the summer vacation as has been customary. Each of the one-hundred and sixty registrants was presented with a copy of the booklet "Effective Teaching" published by the McGraw Hill Book Company and sponsored by the ASEE. It may be noticed that this conference or school was held on a Section basis rather than on a Division basis.

Several questions have been raised regarding the operation of summer schools and a Committee has been giving it some thought this past year. The majority of this Committee seem to feel there is some question as to whether the name should be changed to a Conference, Seminar, or some other designation (but are not ready to recommend a change) and whether the designation "summer" should remain. It is agreed emphasis should be placed upon the attendance of young men but, at the same time, the advice of those experienced in the teaching field is vital. It is thought that the size of the summer school should depend upon the arrangement of the program and what subject matter is being presented. It is thought that summer schools should be devoted to problems in teaching, new methods of presentation, organization of curricular material, and similar topics, with concrete examples of how the teaching may be done, rather than include involved discussions of technical matters, research, etc. This Committee sees no reason why the number of summer schools authorized by the Executive Committee of the Society should be limited in any one year. Schools should be held where the cost of attending the school and transportation is a minimum. Summer schools held in connection with the Annual Meeting are very desirable but only a limited number can be accommodated at that time. The length of summer schools may well be from three days to one week.

A summer school for Physics teachers was contemplated either at Northwestern University or Pennsylvania State College or at both schools, to be sponsored by the American Association of Physics Teachers and the Physics Division of the ASEE. It was felt that there was not sufficient time to organize the school this year and that it should be postponed.

With the discontinuance of accelerated programs for veterans, it should be possible again to build up this important activity of the Society which had been growing up to the beginning of World War II. It is submitted that a summer school project is a worthy challenge to any Division.

Respectfully submitted,

B. J. ROBERTSON, *Vice-President for Instructional Divisions*

Report of Secretary

During the [illegible] completed [illegible] projects and [illegible] areas [illegible] making [illegible] the improvement [illegible] been made [illegible] relationships [illegible] gireering [illegible] colege [illegible] problems [illegible] constru[illegible] the Fe[illegible] [illegible]

Imp[illegible]

[illegible] is the [illegible] jective [illegible] Effective [illegible] fessor Fred M[illegible] Manage[illegible] teachers [illegible] sidered [illegible] methods. [illegible] supply [illegible] ulty [illegible] is the publisher [illegible] Society [illegible] to bring [illegible] Society [illegible]

The second [illegible] aimed at the [illegible] of [illegible] ing education [illegible]

[illegible] Improvement [illegible] Teach[illegible] This [illegible] was distributed by the [illegible] effectiveness of [illegible] [illegible]

It is expected [illegible] would [illegible] problem [illegible] classroom as. This program would also bring pressure to bear upon the companies to

seek the advice of engineering teachers before proceeding with the construction of teaching aids which are intended for engineering instruction. The Committee plans to solicit funds from industry to defray the cost of the project.

An exhibit of ingenious teaching aids prepared by engineering teachers for their own classroom use was held at the Annual Meeting of the Society.

Employment and Manpower

In recent months the Society has undertaken two projects in cooperation with administrators of engineering colleges. One was an attempt to increase the number of job opportunities for engineering students graduating in 1950 and 1951, and thereby assist the engineering colleges in their placement problem during this period when the graduating classes are abnormally large. The second project was that of helping to counteract the sharp decline in engineering enrollments at the freshman level. Both problems are national in scope and exemplify ways in which coordinated action through the Society can be of direct assistance to engineering college administrators.

The first problem—that of expanding the job opportunities for engineering graduates—was efficiently handled by the Society's Division of Relations With Industry. A small brochure entitled "Engineers Offer New Frontiers" was prepared by Mr. Hellwarth and other members of the Division for widespread distribution to industry, particularly to the smaller companies and non-technical industries which normally do not hire engineers. This brochure points out that modern industry is turning more and more to the engineer to solve its highly complex technological, production, and managerial problems. It suggests that many companies can profitably strengthen their organizations and improve their competitive positions by hiring engineering graduates during this brief period when the supply is plentiful. It also describes how company representatives can utilize the personnel services of engineering colleges. The brochures were printed by the Society and over 25,000 have been distributed by engineering colleges throughout the country.

The opposite phase of the problem—that of reversing the decline in engineering enrollments—appeared to be primarily a public relations problem. This was effectively handled by the Administrative Council's Manpower Committee. Vice President Armsby, working in cooperation with the Manpower Committee, prepared an article entitled "Engineers—Too Many or Too Few." The article appraises the supply and demand of engineering graduates in the years ahead and emphasizes the probable deficiency in the number of engineering graduates three or four years hence, owing to the sharp decline in new enrollments. This article was published in Higher Education, and was widely distributed to high schools, engineering colleges, and the public press.

In June 1950, the Manpower Committee made a telegraphic survey of employment of June graduates. This survey showed that approximately 80% of June graduates either were placed or had accepted job offers, thus disproving the misconception of a serious oversupply of engineers. The results of this survey have been released to the public press. A more recent release of the Manpower Committee points out that there is indicated a serious shortage of engineers due to sharp reductions in the number of engineering graduates.

Unification of the Profession

A development of considerable importance to all engineers is the series of conferences now being held on unity of the profession. A committee composed of representatives from sixteen major engineering societies is studying various proposals for the formation of a unifying engineering society, which would represent the entire profession, particularly in matters relating to legislative proposals bearing on engineering, relationships between the engineering profession and the

government, and other matters of public policy. President Saville has been an active participant in these discussions as the Society representative.

The Committee deliberations are now in the early exploratory stage and considerable work has yet to be done before specific proposals are turned over to the engineering societies for their consideration. Your Officers will endeavor to keep the Society membership informed on the progress of these important developments.

Atomic Energy Conference

Recently a proposal was made by President Saville to the Atomic Energy Commission to organize a series of regional conferences to be held under the joint sponsorship of the Society and the Atomic Energy Commission. The proposal was accepted by the Atomic Energy Commission and an interim committee containing representatives from each of the Atomic Energy districts, has been appointed to outline preliminary plans for the regional conferences. Regional committees will be appointed to carry out the detailed planning of the regional conferences.

Costs of Engineering Education

Considerable apprehension has been expressed by administrators of universities and colleges over the problems associated with the financing of higher education. The Association of American Universities has recognized the problem of financing higher education as a strategic national problem which is deserving of critical analysis. Accordingly, they have requested and received grants from the Rockefeller Foundation and the Carnegie Corporation to conduct a comprehensive study, which would include an analysis of the costs and the methods of financing higher education. Your Society has accepted an invitation from the Association of American Universities Commission to appoint an Advisory Committee to assist this Commission in formulating policies and procedures relating to that portion of the study dealing with the costs of engineering education. This project will probably get under way this fall.

National Science Foundation

Your Society, through its Engineering College Research Council, has vigorously and energetically promoted passage of the National Science Foundation legislation. The enactment of this bill constitutes a significant accomplishment of this Society as well as of the Engineers' Joint Council and other cooperating organizations. The Society has cooperated with the Engineers' Joint Council in the preparation of a list of leading engineering educators as nominees for the Science Foundation Board.

Utilization of Engineering Colleges in a National Emergency

Several engineering deans have expressed concern over the need for collaboration between the Society and the U. S. Military Establishment in the preparation of educational plans in the event that a national emergency should arise. It is believed that advanced planning might avoid the confusion and pitfalls of a hastily, extemporized educational program.

Your President has corresponded with top-level authorities in the Military Establishment, offering the cooperation of the Society in formulating such plans and suggesting that the planning might include:

(1) A prediction of the numbers of scientific, engineering, and technological personnel needed;

(2) The planning of specific educational programs at all levels from subprofessional to post-graduate;

(3) An adequate plan for draft deferment of students, research personnel, and engineering teachers.

This problem will be considered further by the Committee on Military Affairs of the Administrative Council.

Summer Schools

This year, the Society sponsored four Summer Schools. These included: Engi-

neering Mechanics at Iowa State College, Social Humanistics at the University of Washington, Civil Engineering (Photogrammetry) at University of Denver, and a teaching symposium sponsored by the North Midwest Section.

M[illegible] ECAC [illegible] ECRC

The ECAC and ECRC held highly successful meetings in Kansas City in November 1948. The program [illegible] Administrative Council [illegible] papers on the [illegible] Opportunities [illegible] Nuclear Engineering [illegible] Research Council [illegible] Purd[illegible]

[illegible]

[illegible] of the [illegible] Annual Meeting [illegible] formulat[illegible] Annual Meeting [illegible]

It is becoming increasingly evident that the relationships between the Society and the federal government are expanding rapidly. In the past there has been no coordination between various groups within the Society which deal either directly with government agencies or which make recommendations with regard to federal legislative measures. President Saville has proposed that a coordinating committee be appointed to interrelate various groups within the Society which have relationships with the government. This would avoid duplication of effort, serve to keep the various committees informed of the direction and progress being made, and prevent cross-purpose actions.

During the past year the Society has cooperated with the U. S. Office of Education in the [illegible] of engineering [illegible] It [illegible] indispensable [illegible] during th[illegible]

D[illegible]

A [illegible] H. Mc[illegible] Engineering [illegible] Technical Institutes [illegible]

[illegible] Division [illegible] Relations With Industry [illegible] Technical Institute Division [illegible] Cooperative Engineering Division [illegible]

The S[illegible] the Secretary [illegible] Section officers.

N[illegible]

A manual [illegible] Cooperative Engineering Education at the Graduate Level, consisting of [illegible] of papers presented at [illegible] meeting of the Divisions of Graduate Studies and Cooperative Engineering in Troy, N. Y. in June 1949, is now available in the Secretary's Office at the price of thirty cents per copy.

A small booklet, "Speaking Can Be Easy for Engineers," which was prepared

by the Committee on Relations with Industry, is now available at fifty cents per copy and can be purchased from the Engineers' Council for Professional Development, 29–33 West 39th Street, New York 18, N. Y.

The ECRC has announced publication of its proceedings which includes papers given before the Research Council in Troy, N. Y., June 1949. The price is $1.50 to ASEE members; $2.00 to nonmembers.

Participation in the Activities of Other Societies

The Society continued its active participation in the Engineers' Council for Professional Development, the American Council on Education, the American Association for the Advancement of Science, the Educational Testing Service, the National Research Council, and the American Standards Association. Society representatives have been appointed to all of these organizations and in a number of cases the Society, through its representative, has contributed significantly to the work of these organizations.

Membership

The Membership Committee has done a superb job again this year in adding over 1000 new members to our membership rolls. They deserve our very hearty congratulations for their outstanding success.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

College Notes

The **University of Missouri** is establishing an engineering extension program under the Adult Education and Extension Service to extend the services of the College of Engineering to the profession and industry of Missouri. Professor R. T. Quick is in charge of the program and will work closely with the staff of the College of Engineering. Programs will be conducted in the State or on the campus by means of conferences, brief and intensive short courses of several days duration, credit and non-credit extension classes, and correspondence instruction.

The Department of Aeronautical Engineering of the **University of Texas** has announced the establishment of a new degree program, leading to the Bachelor of Science degree in Meteorology, beginning in September 1950.

The appointment of Prof. Harry J. Loberg as director of Sibley School of Mechanical Engineering at **Cornell University** was announced by Acting President Cornelis W. de Kiewiet. A member of the Cornell faculty since 1934, Professor Loberg became acting director last year.

Report of Treasurer, 1949-1950

Evanston, Illinois
July 15, 1950

Mr. James S. Thompson, Treasurer
American Society for Engineering Education
Evanston, Illinois

Dear Mr. Thompson:

In accordance with your instructions we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1950 and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Changes in Funds
Exhibit III—Comparative Statements of Income and Expense
Exhibit IV—Comparative Statements of Receipts and Disbursements

In connection with the statements as of June 30, 1950, we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

In accordance with a resolution of the Board of Directors, the excess of income over expense for the year ending June 30, 1950, amounting to $7,543.07, has been transferred to a Reserve for Special Projects, and so appears on the balance sheet.

The Reserve for ECRC of $1,315.03, shown on the balance sheet, represents the accumulated excess of receipts over disbursements for the past four years.

In our opinion these statements fairly present the position of the Society at June 30, 1950 and the results of its operations for the period then ended.

Yours truly,

Ernest C. Davies
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMPARATIVE BALANCE SHEETS

	June 30, 1949	June 30, 1950
Assets		
Current Fund:		
Cash in State Bank & Trust Co.	$38,512.44	$26,280.79
Cash in Mellon National Bank	689.42	———
Petty Cash Fund	300.00	300.00
U. S. Government Bonds Series G	20,700.00	30,700.00
	$60,201.86	$57,280.79
Life Membership Fund:		
Cash—Checking	$ 129.70	$ 155.87
U. S. Government Bonds Series G	1,000.00	1,000.00
	$ 1,129.70	$ 1,155.87

B. J. Lamme Fund		
Cash—Checking	$ 335 89	$ 276 93
Principal Cash in Hands of Trustee	9 00	9 00
Securities and Mortgage	5 132 73	5 132 73
	$ 5 477 62	$ 5 418 66
Accounts Receivable		
Advertising	$ 1 855 00	$ 2 503 85
Less Reserve for Bad Debts	315 00	315 00
	$ 1 540 00	$ 2,188 85
Dues	1 200 00	1 400 00
Brochures		631 20
Westinghouse Educational Foundation	109 58	209 73
Income Cash in Hands of B. J. Lamme Fund Trustee	110 71	121 44
	$ 2 960 29	$ 4 551 22
Inventory (Nominal)	$ 1 00	$ 1 00
Furniture and Fixtures	748 78	748 78
Total Assets	$70 519 25	$69 156 32
Liabilities		
Current Liabilities		
Accounts Payable—Publications	$ 1 600 00	$ 2 110 54
Other Accruals	105 86	371 87
	$ 1 705 86	$ 2 482 41
Prepaid Membership Dues	$ 1 099 75	$ 1 195 20
Funds		
Life Membership Fund	$ 1 129 70	$ 1 155 87
B. J. Lamme Fund	5 477 62	5 418 66
General Education Fund	14 950 00	9 950 00
Carnegie Corporation	4 745 21	—
	$26 302 53	$16 524 53
General Fund		
Reserve for E.C.R.C.		$ 1 315 03
Reserve for Special Projects		7 543 07
Unappropriated Surplus	$41 411 11	40 096 08
	$41 411 11	$48 954 18
Total Liabilities and Net Worth	$70 519 25	$69 156 32

COMPARATIVE STATEMENT OF CHANGES IN FUNDS

GENERAL EDUCATION BOARD, SE SECTION	12 Months Ended June 30, 1949	12 Months Ended June 30, 1950
Balance at Beginning of Period	$17,450.00	$14,950.00
Less: Charges during the Period	2,500.00	5,000.00
Balance at End of Period	$14,950.00	$ 9,950.00

CARNEGIE CORPORATION, ENGINEERING SALARY SURVEY		
Balance at Beginning of Period	$ 5,730.72	$ 4,745.21
Add: Transfer to General Fund for Charges made against it in 1948	269.28	———
	$ 6,000.00	$ 4,745.21
Less: Expense for the Period	$ 1,254.79	$ 3,000.92
Refund to Carnegie Corporation	- - -	1,744.29
	$ 1,254.79	$ 4,745.21
Balance at End of Period	$ 4,745.21	—

SURPLUS GENERAL FUND		
Balance at Beginning of Period	$37,133.84	$41,411.11
Add: Income credited to Lamme Fund in 1948 instead of General Fund	116.11	———
Summer School Fund previously independent of General Fund	689.42	———
Excess of Income over Expense for the Period	3,741.02	7,543.07
	$41,680.39	$48,954.18
Less: Transfer Charge for Carnegie Salary Survey	$ 269.28	———
Restriction of Surplus for ECRC Reserve	---	$ 1,315.03
Restriction of Surplus for Special Projects Reserve	- —	7,543.07
	$ 269.28	$ 8,858.10
Balance at End of Period	$41,411.11	$40,096.08

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	12 Months Ended June 30 1949	12 Months Ended June 30 1950	Budget 1950-51
Income			
Current Dues—Individual	$33 145 83	$38 468 18	$39,000
—Institutional	6 862 50	7 010 00	7 000
Sale of Publications	1 793 78	3 341 30	1,800
Advertising	8 354 68	10 045 16	9 000
Interest on Government Bonds	542 50	667 50	700
Refunds	74 89	—	—
ECRC	2 053 94	1 031 75	—
Income—B. J. Lamme Fund	110 71	10 73	—
Miscellaneous		39 22	—
Total Income	$52 938 83	$60 613 84	$57 500
* Special projects reserve			$7 543 07
Expense			
Cost of Publications	$20 542 29	$23 632 60	$24 800
Administrative Salaries	9 545 40	10 922 10	11 000
Retirement Emeritus	1 360 00	1 360 00	1 360
Postage, Telephone & Telegraph	1 816 19	1 595 50	1 800
Supplies & Sundry Printing	2 177 45	2 052 68	2 350
Dues—American Council on Education	100 00	100 00	100
Contribution ECPD	500 00	500 00	500
Officers Traveling Expense	825 85	1 510 91	2 000
President's Expense		—	500
Travel—Secretary's Office	788 47	989 94	950
Provision for Bad Debts	315 00		
Expenses 1949 Meeting	2 040 78		—
Expenses 1950 Meeting		2 737 84	2 700
Expense ECAC	398 77	733 41	2 200
Expense ECRC	7 051 08	4 344 18	4 350
Committees and Conferences	487 06	609 95	1 700
Expenses—Lamme Fund	239 03		—
Special Projects and Contingencies	1 010 41	1 991 65	5 000
Total Expense	$49 197 81	$53 070 77	$61 310
Excess of Income over Expense	$ 3 741 02	$ 7 543 07	

* On June 19, 1950 the Executive Board voted to set aside the excess of income over expense for the 1949-50 fiscal year as a special projects reserve fund.

COMPARATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS

	12 Months Ended June 30, 1949	12 Months Ended June 30, 1950
Balance at Beginning of Period	$37,175.25	$39,201.86
Receipts:		
Current Dues—Individual	$31,666.58	$35,435.18
—Institutional	6,662.50	7,010.00
Back Dues	1,100.50	1,733.25
Dues in Advance	1,099.75	1,195.20
Sale of Publications	1,915.75	2,710.10
Advertising	8,354.68	9,396.31
Interest on Bonds	542.50	667.50
ECRC	2,053.94	1,031.75
Westinghouse Educational Foundation	250.00	222.29
Lamme Fund Income	113.87	——
Refunds	74.89	——
Summer School Transferred to General Fund	689.42	——
Miscellaneous	——	39.22
Total Receipts	$54,524.38	$59,440.80
Disbursements:		
Cost of Publication	$20,310.56	$23,122.06
Administrative Salaries	9,545.40	10,922.10
Retirement Emeritus	1,360.00	1,360.00
Travel—Secretary's Office	788.47	989.94
Postage, Telephone and Telegraph	1,776.72	1,656.67
Supplies and Sundry Printing	2,177.45	2,052.68
Dues—American Council on Education	100.00	100.00
Contribution ECPD	500.00	500.00
Officers Traveling Expenses	825.85	1,510.91
Expenses 1949 Meeting	1,989.39	——
Expenses 1950 Meeting	——	2,422.36
Expenses ECAC	398.77	733.44
Expenses ECRC	7,051.08	4,334.18
Committees and Conferences	472.06	598.25
Westinghouse Award	200.00	322.44
Expense—B. J. Lamme Fund	236.79	——
Special Projects and Contingencies	1,010.44	1,991.63
Expense—Carnegie Survey	1,254.79	4,745.21
Award—General Education	2,500.00	5,000.00
Purchase of Government Bonds	——	10,000.00
Total Disbursements	$52,497.77	$72,361.87
Balance at End of Period:		
Checking—State Bank and Trust Co., Evanston	$38,512.44	$26,280.79
Savings—Mellon National Bank, Pittsburgh	689.42	——
	$39,201.86	$26,280.79

Respectfully submitted,

JAMES S. THOMPSON,
Treasurer

Minutes of Executive Board Meetings

A meeting of the Executive Board of The American Society for Engineering Education was held on Monday, June 19, 1950 at the University of Washington, Seattle, Washington. Those present were: Thorndike Saville, *President*, H. H. Armsby, A. B. Bronwell, F. M. Dawson, B. J. Robertson, J. H. Lampe (representing F. E. Terman), M. M. Boring (invited guest), and M. Strohm.

A number of items considered by the Executive Board were referred to the General Council. These items are reported in the Minutes of the General Council Meetings.

Report of the Secretary

The Secretary presented a written report summarizing the year's activities. This report is published in this issue of the *Journal*.

Report of the Treasurer

The report of the Treasurer was presented, including the tentative annual audit, which was accepted by the Board. The Board approved the proposed budget for 1950–51 with the following provisions:

a. A grant of $2,400 was approved for use of the Committee on Improvement of Teaching for this year only. If further financing is needed at the end of the year, an appeal would be made to other sources to defray at least part of the expenses.

b. A motion was approved to allot an amount up to $1,000 for the joint use of the Manpower Committee and a corresponding committee of EJC for a survey of employment of 1950 engineering graduates. The survey will lead to an analysis of types of jobs filled by engineering graduates.

c. The Board voted to set aside the 1949–50 excess of income over expenses as a Special Projects Reserve which can be drawn upon for special projects undertaken during the coming year.

Unity of the Profession

President Saville reported on progress which was being made by the Committee on Unity of the Profession, representing sixteen major engineering societies. This report is described more fully in the Minutes of the General Council Meeting.

President Saville reported that he had investigated tentatively whether or not the Engineers' Joint Council would be receptive to ASEE membership in EJC. All but one of the constituent societies of the EJC favor ASEE membership, the dissenting society officers expressing the opinion that ASEE membership in EJC should be deferred pending the outcome of the Unity of the Profession Conference.

Cooperation With the Military Establishment in Planning Emergency Educational Program

President Saville reported on the steps which he had taken to establish relationships with the U. S. Military Establishment in planning educational and research programs in the event of a national emergency. His report is summarized in the Minutes of the General Council Meeting.

Secondary Schools

The Secretary reported on a letter he had received, commenting on the inadequacy of secondary school education. The Board recommended that the letter be referred to the Committee on Secondary Schools.

Application of Howard University for Membership

The Board unanimously voted to approve the application of Howard University for active institutional membership in the Society.

Branches at University of Tennessee and Texas A & M

The Board approved requests for Branches of the Society at the University of Tennessee and Texas A & M, subject to the approval of the Committee on Sections and Branches.

Annual Meeting in 1952

It was moved and seconded to accept the invitation of Dartmouth College to hold the Annual Meeting in 1952 on their campus. The Board recommended that this invitation be presented to the General Council for their approval at the Council Meeting on Monday evening.

Appointment of the Secretary

The Board voted to reappoint Arthur B. Bronwell Secretary of the Society for the year 1950–51.

Fall Meeting of ECAC and ECRC

It was announced that meetings of ECAC and ECRC would be held in Washington, D. C. during the week of the Land Grant College meetings, November 13 17, 1950.

A meeting of old and new members of the Executive Board of The American Society for Engineering Education was held on Wednesday, June 21, 1950 at the Meaney Hotel in Seattle, Washington. Those present were: Thorndike Saville, *President*, H. H. Armsby, A. B. Bronwell, F. M. Dawson, L. E. Grinter, B. J. Robertson, G. A. Rosselot, C. L. Skelley, F. E. Terman, and M. Strohm.

Publication of Article on Standardization

The Board voted to publish an article on the subject of Standardization, not to exceed three pages in length, in the JOURNAL OF ENGINEERING EDUCATION, after referring it first to the Mechanical Engineering Division for possible program material.

ASEE Policy Regarding Branches in Technical Institutes

An application for a Branch of the Society in an ECPD accredited Technical Institute has raised the question as to what the policy of the Society should be with respect to Branches in Technical Institutes.

The Executive Board expressed sympathetic interest in the encouragement and recognition of such groups, but as it is a new problem with important professional implications, the Board recommended to the Council that the matter be investigated by the Vice President in charge of General and Regional Activities and be reported to the next meeting of the Executive Board for action at the Fall Meeting of the Council.

Civil Engineering Summer School

The Executive Board voted to approve ASEE sponsorship of a Summer School in Photogrammetry in Civil Engineering at the University of Denver on August 7–11, 1950.

ECRC Budget

The Executive Board voted to allocate to the ECRC $1,000 to assist in the publication of "Current Research" in addition to the ECRC budget of $3,350.

Study of Annual Meetings

The Board requested the Secretary to make a study of the last three Annual Meetings of the Society for the purpose of securing information on the cost of meals, deficits, accommodations, how they were underwritten, what reasonable costs were for the different services, etc.

Institutional Membership in Sections

The question has been raised as to whether or not members representing industrial organizations can form a Section. The Executive Board expressed the opinion that each Section should include a minimum of two Active Institutional members.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Minutes of General Council Meetings

Report of the Secretary

The Secretary reported briefly on the progress of several current projects as follows:

(a) The manual, "Effective Teaching," has been published and approximately 10,000 copies have been sold in the three months since it was announced.

(b) A brochure, "Engineers Offer New Frontiers," prepared by the Division of Relations With Industry for the purpose of expanding employment opportunities for engineers, had been widely distributed to industries throughout the country.

(c) Over 13,000 copies of Mr. Armsby's article, "Engineers—Too Many or Too Few," have been distributed to engineering colleges, the public press, and high schools throughout the country in an effort to reverse the decline in engineering enrollments.

(d) The Secretary reported briefly on the progress of the Teaching Aids project and stated that the Committee is planning to solicit funds from industry to defray the cost of handling the project.

Report of the Treasurer

The Treasurer's report was presented, including the tentative annual audit and the budget for 1950-51. The cash position of the Society has decreased due to three items: (a) purchase of $10,000 worth of government bonds during the year, (b) the payment of approximately $5,000 to the Southeast Section out of a special grant made by the General Education Board, and (c) a special grant made by the Carnegie Corporation for a salary survey to be conducted by the Society was closed, and the balance was returned to the Carnegie Corporation, resulting in cash payments of approximately $5,000.

Tax Exempt Status of the Society

The Secretary announced that the Society has inquired of the Treasury Department as to its income tax status. The Treasury Department has ruled that the Society is tax exempt and that gifts made to the Society are also tax exempt.

Unity of the Engineering Profession

President Saville reported on the progress of Conferences on "Unity of the Engineering Profession." He stated that representatives of 16 engineering organizations have met under the auspices of the Engineers Joint Council to explore ways and means of effecting an organization which would merge the public interest of the engineers and would have power to speak with authority to the government and the public on broad problems having engineering implications. He reported that a Planning Committee of eight members had met on numerous occasions to formulate specific proposals. The following three plans were initially proposed:

(a) A Unity Organization consisting of the existing National Society of Professional Engineers, with modifications to remove the requirement of professional registration for membership.

(b) An expansion of the existing Engineers' Joint Council providing for participation by all of the major professional engineering societies. This would be essentially a council-type organization as distinguished from the individual membership organization proposed by the NSPE.

(c) A compromise organization consisting of a council with representatives from the principal engineering societies and also providing for individual membership.

Later, a fourth plan was proposed which contemplates the expansion of the EJC to form a council-type of organization, but in addition providing for individual membership. All of these plans are now under consideration and specific proposals will be submitted to the participating societies at some future date. President Saville emphasized that the Constitution of the Unity Organization will undoubtedly have a minimum requirement for membership consistent with the present membership designations adopted by the ECPD. He stated that in his opinion it is vitally important for the Society to uphold its professional membership status in order not to jeopardize its future affiliation with the Unity Organization.

Report of Vice-President Armsby

Vice-President Armsby reported that a Sections Manual had been completed for use of Section Officers. He stated that the Manual is in tentative form and that his Committee on Sections would appreciate corrections from the Sections Officers during the year.

Vice-President Armsby stated that he had held several conferences with members of the State Department on the Point Four Program. He stated that the legislation had been enacted, although there was no appropriation. The Point Four Program would be administered by an Advisory Board consisting of not to exceed thirteen persons appointed by the President with the consent of Congress. In addition, there will be a number of committees serving in various specialized fields.

A request that the Committee on Sections be designated the Committee on Sections and Branches was approved by the Council.

Atomic Energy Conferences

At the suggestion of President Saville, a Steering Committee consisting of five members representing the five areas of the Atomic Energy Commission has been formed to plan a series of atomic energy conferences. The purpose of these conferences is to facilitate a flow of information on nuclear engineering into the engineering curricula. The following objectives were outlined by the Steering Committee:

(1) To evaluate the responsibilities of engineering education in aiding the growth and development of the atomic energy industry and to determine what there is in the development of nuclear engineering which can be used to enrich and strengthen engineering education.

(2) To assess the over-all needs for engineers with special training in nuclear engineering.

(3) To explore with AEC and its contractors subjects or fields of research which may be carried out by graduate students or engineering faculties.

(4) To define the needs of educational institutions with respect to instructional materials, (a) for the modification of existing courses in basic science and engineering, (b) for the modification of standard engineering curricula, and (c) for advanced training for engineers planning to specialize in nuclear engineering.

(5) To formulate plans for facilitating the flow of needed information regarding such instructional materials to the engineering schools.

Subcommittees will be appointed in each of the Atomic Energy Commission districts to plan the conferences. It is contemplated that they will consider:

(1) The organization of regional meetings to be attended by members of engineering faculties and representatives of AEC and its contractors.

(2) Temporary employment and exchange programs with AEC laboratories.

(3) Study of the needs of the atomic energy industry for engineers.

(4) Study of the kinds of published materials now available relating to these applications.

(5) Methods by which colleges and universities may make use of experts from AEC installations.

(6) Methods by which information about engineering applications may be

further identified and transmitted to colleges and universities in a useful manner.

(7) Cooperation with AEC in a program for declassification of engineering information as security permits.

Report of Vice-President Robertson

Vice-President Robertson reported on the excellent cooperation which the Society headquarters had received in handling the program arrangements for the Annual Meeting. He also commented on the constructive work of the conference of Division and Committee Chairmen.

Vice-President Robertson reported on the progress which his Committee on Summer Schools is making in their study of various types of Summer School programs. He pointed out that the University of Minnesota had originated a new innovation in Summer Schools, having held a Summer School devoted entirely to teaching methods and the science of teaching. He emphasized the importance of getting the younger faculty members to attend Society sponsored Summer Schools.

Report of the ECRC and ECAC

Vice-President Dawson submitted his written report and presented a new publication, "Research is Learning," which the ECRC had just completed.

J. H. Lampe reported on the activities of the ECAC. He briefly discussed the progress of the various committees of the ECAC and also reported on the success of the Conference at Kansas City last fall. He pointed out that considerable attention is being given by the Administrative Council t the problem of the supply and demand of manpower and stated that attempts would be made to determine more precisely what types of employment are accepted by engineering graduates in order to evaluate the demand for engineering graduates.

Coordinating Committee on Relations with the Government

President Saville briefly outlined his previous proposal that a Coordinating Committee on Relations with the Government be appointed. He stated that he had thus far been unsuccessful in getting a properly qualified person to accept Chairmanship of this Committee. He pointed out that there are numerous vital problems bearing on military educational programs, ROTC, and other government relations which should be coordinated through one central committee in order to avoid duplication of effort and cross purpose.

Registration Fee at the Annual Meeting

There was considerable discussion as to whether or not a registration fee should be charged at future Annual Meetings of the Society. It was pointed out that Rensselaer Polytechnic Institute experienced a substantial deficit as a result of their Annual Meeting. The University of Washington requested permission to charge a registration fee in order to avoid a deficit and accordingly, a $3.00 registration fee was authorized. It was pointed out that the cost of an Annual Meeting had increased substantially in recent years by virtue of the larger attendance and also the general inflation in prices. Two alternatives were discussed: (a) to charge a registration fee, and (b) to add an increment to the cost of the meals.

A registration fee would be paid uniformly by all persons attending the Annual Meeting. The increased meal cost would be borne by only those attending luncheons and dinners and would tend to discourage attendance at the luncheons and dinners. The possibility of raising the deficit from local merchants was also discussed. The opinion was expressed that our Society should be able to support its Annual Meetings without being in the position of soliciting funds from outside sources. It was also pointed out that it was undesirable for the host institutions to bear a substantial deficit since this would quickly discourage invitations from some of the more desirable schools.

A motion that the Council should not authorize charging of registration fees in the future was passed.

Pooled Travel Expense Plan

A proposal was presented which would provide for a travel expense pool, with each of the participating colleges contributing to the pool in order to provide expenses for representatives from each institution to attend the Annual Meeting of the Society. It was pointed out that state institutions could not participate in this plan, since it would be illegal in most states. A motion rejecting the plan was therefore passed.

Annual Meetings for 1951 and 1952

President Saville announced that the Annual Meeting for 1951 would be held at the Michigan State College, June 25–29, 1951, and that the 1952 Meeting would be held at Dartmouth College, June 23–27, 1952.

General Problems

A proposal was made that the Council consider three problems as follows:

(a) The possibility of holding a Summer School for engineering deans to present discussions on administrative problems in engineering colleges. It was pointed out that the Administrative Council had such a program planned for the Annual Meeting in Seattle, which consisted of a closed meeting for administrators of engineering colleges. This suggestion was referred to the Administrative Council.

(b) There is a serious ambiguity in our college system in that, despite the universally recognized need for a broad education for engineering students, it has been the practice of engineering colleges to populate their teaching staffs with highly trained specialists.

(c) It is generally recognized that there is a need for teaching excellence at the freshman and sophomore years in order that the engineering students get a sound foundation. Despite this need, the status of faculty members teaching freshman and sophomore subjects has been so degraded that good faculty members resent these teaching assignments. The Council voted to refer the second and third problems to the Committee on the Improvement of Teaching.

It was voted that the Division of Educational Methods should recommend to the Executive Board the objectives and scope of Summer Schools.

The Secretary pointed out that the Point Four Federal Legislation could provide substantial sums for education of foreign students in this country and suggested that a Committee of the Society might prepare a specific proposal which could be presented to government officials who are planning the Point Four Program, providing for scholarships and fellowships for foreign students who are interested in studying science and technology in this country. This suggestion was referred to the Committee on International Relations.

Life Membership

The following persons meet all of the requirements for life membership in the Society and the Council voted to grant them life membership: R. S. Crossman, Paul Cloke, Arthur S. Hill, Albert R. Johnson, Carl A. Norman, F. M. Porter, Charles E. Thomas, L. F. Van Hagan, J. R. Withrow.

Delinquent Members

The Council voted to drop eighty members of the Society who were delinquent more than two years in dues.

Resolution to Host Institution

A resolution thanking the host institution for their hospitality to the Council members and their wives at the Council Dinner was unanimously approved.

A meeting of old and new members of the General Council was held at the University of Washington, Seattle, Washington, on Friday morning, June 23, 1950. Those present included: Thorndike Saville, *President,* F. M. Dawson, H. H. Armsby, B. J. Robertson, F. E. Terman, C. L. Skelley, A. B. Bronwell, L. E. Grinter, H. J. Barre, E. C. Clark, H.

H. Wheaton, H. K. Justice, K. L. Holderman, C. A. Brown, O. N. Olson, L. O. Stewart, T. L. Joseph, L. G. Miller, W. M. Lansford, H. W. Barlow, R. S. Paffenberger, R. P. Holescher, M. P. Capp, R. D. Landon, R. Z. Williams, H. R. Beatty, O. E. Osburn, W. H. Carson, W. T. Alexander (for E. R. McKee), R. L. Shurter (for J. E. Thornton), and M. Strohm.

Branches in Technical Institutes

The Secretary presented the recommendation of the Executive Board relating to the policy of the Society in forming Branches in Technical Institutes. The Council recommended that the matter be investigated by the Vice President in Charge of General and Regional Activities and be presented to the Executive Board and Council for action at the fall meeting.

Registration Fees

H. H. Wheaton requested the Council to reconsider its previous motion prohibiting registration fees at future Annual Meetings. He stated that a number of members with whom he had talked expressed the opinion that this action would either result in abnormally high charges for luncheons and dinners, thereby limiting attendance at the luncheons and dinners, or it would place a financial hardship upon the host institution. President Saville expressed the view that the resolution passed by the Council should not be regarded as an iron clad rule, and that if evidence in the future indicates that the host institution will suffer a substantial deficit, the matter should be reconsidered by the Council.

Educational Testing Services

H. R. Beatty stated that Mr. Johnson of the Educational Testing Service had requested the Society to express its views as to the future of the engineering tests being constructed and administered by the Educational Testing Service. The declining use of these tests has led the Educational Testing Service to question whether educators and administrators of engineering colleges are interested in continuing the research and operation of this service for engineering colleges, or whether it should ultimately be discontinued. The matter was referred to the Society Committee on Selection and Guidance for study.

Summer Schools

R. L. Shurter presented a request of the Humanistic Social Division for a Society sponsored Summer School to be held at Michigan State College in 1951. The Council approved the request. The Council approved Society sponsorship for a Summer School in Civil Engineering (photogrammetry) at the University of Denver, August 7-11, 1950.

Next Meeting of the General Council

It was announced that the next meeting of the General Council would be held in Washington, D. C., at the time of the meeting of the Land Grant College Association on November 16 or 17, 1950.

Respectfully submitted,

ARTHUR BRONWELL,

Secretary

Candid Comments

ENGINEERING MORALS AND PHILOSOPHY

The coming event which is casting its shadow before it quite plainly in engineering education is the trend toward a serious interest in the moral, ethical, religious and philosophical phases of an engineer's professional training. The occasion for this has been pointed out in two excellent papers published in this Journal last year: the first on "Education and Freedom from Fear," by Dean C. J. Freund of Detroit, and the second on "Value Judgments," by President R. E. Doherty of Carnegie Tech. In a sense this is an extension of the recently developed emphasis upon the "socio-humanistic stem" which now seems firmly established in our curricula. The ethical problem has, however, taken on a new urgency in the post-war world and there is a growing number who feel that engineering educators should no longer dodge the issue by leaving students entirely to their own devices in this area.

Dean Freund has stated the general problem very clearly, and he has also emphasized the fact that before we can effectively help our students in developing a sound professional philosophy we must first, as teachers, agree upon a few basic axioms and a method or approach that will give some semblance of unity and coherence to our efforts. In an attempt to present the matter in somewhat less general and more specific terms, the writer has listed, in a recent letter to President Saville, the following questions which might serve for the agenda for a session on this subject at one of our Society meetings:

1. *Why* should engineers concern themselves with moral questions?
2. To what authority should we appeal in cases of doubt or disagreement in specific ethical questions?
3. Do we sincerely subscribe to the principle implicit in: "My country, may she always be right, but, right or wrong, my country!"?
4. Do we really believe that each individual is a free and independent moral agent (enjoying "free will"), or to what extent is each man's behavior conditioned inexorably by his heredity and his environment?
5. Can we recognize any "natural law" in the area of ethics and morals—something fundamental enough to command universal respect among men of all faiths and creeds?
6. What should be the primary and basic compulsion impelling engineers to virtuous behavior?

Although some of these questions are highly controversial, they are of such importance that it would seem eminently worth while if we could arrive at even tentative or arbitrary answers to them, for our particular profession. The interest and encouragement of President Saville and other officers of the Society prompts the writer to urge that we concern ourselves actively with such questions, and with the general issue proposed by Dean Freund.

W. J. King
Professor of Engineering,
University of California,
Los Angeles

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Kansas-Nebraska	Kansas State College	Oct. 13–14, 1950	F. W. Norris, University of Nebraska
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Lehigh University	May 13, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	Naval Ordnance Laboratory	Oct. 3, 1950 Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	University of New Hampshire	Oct. 14, 1950	W. C. White, Northeastern University
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13 & 14, 1950	F. H. Thomas, University of Buffalo

Members of the Society are welcome at all Section Meetings

New Members

ADDISON, ARNOLD, Associate Professor and Personnel Director Ordnance Research Laboratory, Pennsylvania State College, State College, Pa. R. A. Hussey, E. A. Walker.

ALLEN, ALFRED W., Associate Professor of Ceramic Engineering, University of Illinois, Urbana, Illinois. R. K. Hursh, A. I. Andrews.

ALTOZ, FRANK E., Assistant Instructor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. G. B. Thom, A. B. Bronwell.

BABB, DANIEL S., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. J. D. Ryder, C. A. Keener.

BARKSON, JOSEPH A., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. P. K. Hudson, A. L. Barley.

BAUGH, ROBERT L., Instructor of Electrical Engineering, Colorado School of Mines, Golden, Colo. T. E. Payntee, F. R. Campbell.

BERGH, DONALD A., Instructor of Mechanical Engineering, Michigan State College, Lansing, Mich. D. J. Renwick, C. C. Sig er foos.

BOYER, MARION C., Assistant Professor of M & H. State University of Iowa, Iowa City, Ia. C. J. Posey, A. B. Bronwell.

BRANIN, M. LELYN, Chairman, Department of Chemistry, Newark College of Engineering, Newark, N. J. I. P. Orens, G. B. Thom.

BRECKENRIDGE, H. K., Vice President, West Penn Power Company, Pittsburgh Pa. G. Klein, J. C. McKeon.

CHANG, SHURMAN Y., Assistant Professor of Electrical Engineering, University of Massachusetts, Amherst, Mass. R. R. Brown, J. W. Langford.

COUNTS, GERALD A., Professor of Physics and Chemistry, U. S. Military Academy, West Point, N. Y. B. W. Bartlett, R. I. Heinlein, Jr.

DECHANT, WILLIAM G., Assistant Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. W. A. Murray, E. B. Morris.

DELTORO, VINCENT, Instructor of Electrical Engineering, College of City of New York, New York, N. Y. G. J. Clemens, H. Wolf.

EATON, HAROLD D., Assistant Professor of Mechanical Engineering, Michigan State College, Lansing, Mich. L. C. Price, J. M. Campbell.

EDMISON, HAROLD R., Instructor of Engineering, City College of San Francisco, San Francisco, Calif. A. S. Levens, A. E. Edstrom.

ELDIN, HAMED K., Egyptian Government Mission Member, Fuad 1st University, Cairo, Egypt. A. B. Cambel, A. B. Bronwell.

ELIZONDO, YNDALECIO J., Instructor of T & AM, Iowa State College, Ames, Ia. A. W. Davis, A. Higdon.

FEENEY, EDMUND J., Director, Newark School of Industrial Drafting & Design, Newark, N. J. T. J. Fully, F. W. Bauder.

FETTY, HOMER D., Director of Business and Industrial Education, Los Angeles State College of Applied Arts and Sciences, Los Angeles, Calif. B. W. Martin, V. C. George.

GALLIGAN, WILLIAM E., Associate Professor of Civil Engineering, Iowa State College, Ames, Ia. W. C. Alsmeyer, A. Higdon.

GRACIDA, HENRY J., JR., Assistant Instructor of Architecture, University of Houston, Houston, Tex. W. B. Lowe, A. A. Rasmussen.

HAMILTON, HERBERT J., Instructor of Mechanical Engineering, Michigan State College, East Lansing, Mich. L. G. Miller, L. C. Price.

HANG, RICHARD L., Instructor of Engineering Drawing, Ohio State University, Columbus, Ohio. C. D. Cooper, R. S. Paffenbarger.

HARDING, FENTON, Associate Professor of Civil Engineering, Texas Technological College, Lubbock, Tex. F. L. McRee, J. H. Murdough.

HATHAWAY, SAMUEL L., Assistant Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. W.A. Murray, G. C. Barnes, Jr.

HEINE, RICHARD W., Assistant Professor of Metallurgical Engineering, University of Wisconsin, Madison, Wis. P. C. Rosenthal, G. J. Barker.

HEIPLE, LOREN R., Head, Civil Engineering Department, University of Arkansas, Fayetteville, Ark. G. F. Branigan, J. G. Gleason.

HOFFMAN, DWIGHT S., Assistant Professor of Chemical Engineering, University of Idaho, Moscow, Idaho. C. O. Reiser, H. W. Silha.

HORONJEFF, ROBERT, Lecturer and Research Engineer, University of California, Berkeley, Calif. H. E. Davis, R. A. Moyer.

HUTCHINS, JACQUE L., College Service, Educational Department, Westinghouse Educational Center, Pittsburgh, Pa. J. C. McKeon, A. B. Bronwell.

IMM, RUBEN A., Instructor of Electrical Engineering, University of Wisconsin, Madison, Wis. J. C. Weber, L. E. A. Kelso.

IP, CHING-U, Instructor of Mechanical Engineering, Michigan State College, East Lansing, Mich. L. G. Miller, L. C. Price.

KEACHIE, EDWARD C., Associate Professor of Mechanical Engineering, University of California, Berkeley, Calif. E. D. Howe, E. P. De Garmo.

KEARNS, CLYDE H., JR., Instructor of Engineering Drawing, Ohio State University, Columbus, Ohio. R. S. Paffenbarger, H. W. Shupe.

KINTNER, PAUL M., Instructor of Electrical Engineering, University of Illinois, Urbana, Ill. C. A. Keener, J. D. Ryder.

LAKE, WALTER S., Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst, Mass.

LIBBY, WILBUR E., Coordinator of Engineering, Michigan State College, East Lansing, Mich. L. G. Miller, L. C. Price.

McCLELLAN, THOMAS J., Assistant Professor of Civil Engineering, Oregon State College, Corvallis, Ore. G. W. Holcomb, A. B. Bronwell.

McCOLLY, HOWARD F., Professor of Agricultural Engineering, Michigan State College, East Lansing, Mich. A. W. Farrall, D. M. Fullmer.

METZLER, DONALD E., Assistant Professor of M. & H., State University of Iowa, Iowa City, Ia. C. J. Posey, A. B. Bronwell.

MILLER, BRUCE J., Personnel Administrator, Linde Air Products Co., Snyder, N. Y. R. F. McCook, L. E. Stout.

MOWBRAY, ALPHEUS Q., JR., Instructor of T. & A. M., University of Illinois, Urbana, Ill. W. M. Owen, W. M. Lansford.

MURPHY, GORDON J., Instructor in Electronics, Milwaukee School of Engineering, Milwaukee, Wis. A. P. Jones, F. J. Van Zeeland.

NEAL, JAMES P., III, Assistant Professor of Electrical Engineering, University of Illinois, Champaign, Ill. C. A. Keener, M. A. Faucett.

OTIS, FRANKLIN F., Chairman of Mathematics Department, Michigan College of Mining & Technology, Sault Ste. Marie, Mich. H. L. Crawford, A. B. Bronwell.

PARKINSON, RICHARD W., Instructor of Engineering Drawing, Ohio State University, Columbus, Ohio. E. O. Reed, R. S. Paffenbarger.

PAUL, RALPH L., Instructor of Engineering Drawing, Michigan State College, East Lansing, Mich. D. M. Fullmer, C. L. Brattin.

POTESCHKE, WERNER H., Instructor, University of Houston, Houston, Tex. W. T. Kittinger, Jr., W. B. Lowe.

RALPH, JOHN R., Instructor in Mechanical Engineering, University of Tennessee, Knoxville, Tenn. J. W. Walker, R. L. Maxwell.

SHERMAN, THEODORE A., Associate Professor of English, University of Idaho, Moscow, Idaho. C. O. Reiser, H. W. Silha.

SMEDLEY, FRANCIS J., Assistant Professor of Mechanical Engineering, Seattle University, Seattle, Wash. R. Q. Brown, A. B. Bronwell.

SMITH, LISLE A., Professor of Civil Engineering, Michigan State College, East Lansing, Mich. L. G. Miller, L. C. Price.

SMITH, RAY V., Instructor of Mechanical Engineering, Colorado School of Mines, Golden, Colo. F. R. Campbell, T. E. Payntee.

SPANGLER, MERLIN G., Research Professor in Civil Engineering, Iowa State College, Ames, Ia. W. C. Alsmeyer, A. Higdon.

TOMPKINS, LEE L., Assistant Div. Manager C.E.S., Continental Can Co., Inc., Houston, Tex. C. A. Vogt, W. B. Lowe.

WADSWORTH, JAMES D., Assistant Professor in Forging Department, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, J. Coulam.

WEHRLE, J. ALBERT, Dean of Engineering, University of Dayton, Dayton, Ohio. A. J. Holian, A. R. Weber.

WEIKEL, RAYMOND C., Assistant Professor of Aeronautical Engineering, University of Washington, Seattle, Wash. F. S. Eastman, H. E. Wessman.

WHEELER, WILLIAM A., JR., Assistant Professor of Mechanical Engineering, Cornell University, Ithaca, N. Y. A. H. Burr.

WHITLOCK, ERVIN E., Instructor in General Engineering, Purdue University, Lafayette, Ind. M. D. Roberts, J. Rising.

WOMOCHEL, HOWARD L., Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. L. G. Miller, L. C. Price.

WRIGHT, WILLIAM F., Instructor in Engineering Drawing, Ohio State University, Columbus, Ohio. C. D. Cooper, R. S. Paffenbarger.

YADOFF, OLEG, Research Associate, Columbia University, New York, N. Y. N. V. Feodoroff, B. A. Bakhmeteff, A. B. Bronwell.

YARRINGTON, PAUL T., Instructor in Engineering Drawing, Ohio State University, Worthington, Ohio. R. S. Paffenbarger, H. W. Shupe.

65 new members this year

Editorial

Engineering Colleges and National Defense

By HENRY H. ARMSBY

Vice President of the Society and Associate Chief for Engineering Education, U. S. Office of Education

Engineering colleges, in common with all educational institutions, are making it evident that they are eager to make their most effective contribution towards meeting national needs in the present world situation. They played an exceedingly important part in helping to win World War II through their programs of research, of educating future industrial leaders, of training engineers and subprofessional engineers, of training for the armed forces, in short, by their hearty participation in the three-way cooperation of education, industry, and government. It may be well at this time to consider briefly what they can do to serve their country in the present situation, which gives indication of being the beginning of a period of either partial or complete mobilization extending over many years.

The general conditions which the engineering colleges face now are different in several respects from those which faced them when defense efforts were started prior to World War II . Our defense preparations are much stronger than they were in 1940. A large number of industrial plants of all kinds which had to be built from the ground up during World War II are either in service or can be made ready for service with relatively small effort. We have a fair-sized Navy in "moth balls," which can be activated in much less time that was needed to build it. We have more airplanes than we had in 1940, more tanks, more equipment of all sorts, and more men in the armed forces.

But if the present situation should develop into active war, we shall need more trained men, more plants, more equipment. We shall have to make a large and rapid expansion of our armed forces, just as we did in 1940. This will create tremendous industrial needs, with their attendant problems of training.

Many references are made to the huge pool of veterans of World War II, who it is said can be prepared for service very quickly. But a large number of these veterans are unavailable for service, due to age, dependents, or physical disability. Since the number of young men in the age groups most useful for military service is much smaller than in 1940, the use of increased numbers of older men and of women will be necessary.

In 1940 the country had some 8,000,000 unemployed, forming a vast pool for enlistment in the armed forces or for preemployment training. Unemployment now is only about 3,000,000, so that a large proportion of the men called into the military services will leave vacancies in industry. It will be necessary to train other persons to fill many of these vacancies promptly if our economy is to be maintained on an even keel.

It is true that there are large numbers of veterans who have received varying amounts of technical training under the G. I. Bill. There are also a fairly large number of people who received ESMWT training during World War II, many of whom are still using that training or could be retrained for effective industrial

service in a relatively short time. But there has been tremendous technological progress since 1945, and military equipment has in general become much more complicated. A great expansion has taken place in the use of jet planes, rockets, guided missiles, and other military devices. The atomic bomb, which appeared at the close of World War II, may play a prominent part in the next war. The efforts to develop the H-Bomb may create a heavy demand on our engineering and scientific manpower, as did the A-Bomb during 1940–45. Furthermore, most of the veterans and ES MWT trainees are employed now, and if shifted to other employment will have to be replaced.

These differences are mainly differences in degree. Our engineering colleges face the same basic problem they faced in 1940, the problem of making a large and *rapid increase in the number of technically* trained men and women available for use in war industries, to expand these industries and to replace men drawn from them for service in the armed forces. In addition, the colleges face the long-range problem of keeping our democratic society operating. We must keep our educational plant operating to train our future citizens in the ways of democracy, for if we neglect these values, even though we win a war we may lose our democracy.

The following are suggested as some of the means by which the engineering college can help our nation meet its present needs and prepare for the period of peace which we all hope lies somewhere in the future.

The engineering college can strengthen its guidance program. Full-time enrollments will probably decrease because of the calls of students to the armed services and to war industries. It therefore will be more important than ever that each student be encouraged to enter the type of program in which he can be most successful, and hence most useful to his country.

The engineering college can make every possible effort to keep its normal educational program operating as effectively and efficiently as possible. It might consider the advisability of accelerating its program to make engineers available in a shorter time than under its normal program. It is possible that in some locations expansion of the "cooperative" principle of education may be useful both to industry and to the college. As this is written (mid-August) policies announced by the armed forces concerning the calling up of reserve officers and by Selective Service on possible deferment of college students give indications that these agencies are aware of the importance of maintaining a steady flow through the "pipelines" which will supply the future engineers, scientists, and other professional persons our nation must have if it is to maintain the American way of life.

The engineering college can make a *significant contribution to planning for* civil defense in its locality. In this activity it should cooperate with other educational institutions, with local health, police, and fire authorities, and with local agencies established by or through the Federal Government. Some phases of civil defense call for types of training which can probably be done better by engineering colleges than by any other agency.

The engineering college can perform a useful service by cooperation with other educational agencies in the making of community surveys to establish over-all training needs and to determine manpower resources.

The engineering college can play a very important role by providing needed industrial training, either by contracts with local industries or as a part of a reactivated ESMWT program, if one is established. As this article is written, consideration is being given to the possible need for reviving this program, perhaps on a broader basis than ESMWT, not limited to the fields of engineering, science, and management, but authorized to offer training in any field in which an emergency need for college level train-

ing is declared. However, even if it is decided to establish such a program, it will probably require some months to activate it. Meanwhile the engineering colleges need not wait for ESMWT to be revived, but can proceed to meet local training needs by direct contracts with the industries concerned.

The first step of all for an engineering college might well be to establish a college planning committee, which in a university might be a subcommittee of a university planning committee. Such a committee should survey educational facilities and staff in an effort to decide in what ways the engineering college could make its most effective contribution toward meeting a national emergency. Hysteria and hasty action should be avoided. The best interests of the country and of the engineering colleges will be served by an expeditious, but thorough and careful, appraisal of the needs in the area served by the college and by intelligent plans for meeting them. In making these plans it is at least as important for the colleges to suggest the kinds of services they can render most effectively, and which in their judgment will be useful, as it is for governement agencies to plan what services they may ask of educational institutions and their staffs.

* * * *

Washington Meetings of ECAC and ECRC

The following program sponsored by the ECAC and ECRC will consist of panel discussions followed by discussions from the floor. The meetings are open to ASEE members and members of the Engineering Division of the Land Grant College Association.

NOVEMBER 16, 1950

CARLTON ROOM, CARLTON HOTEL

2:30 P.M. TECHNICAL MANPOWER REQUIREMENTS AND MANPOWER CONTROLS

Co-Chairmen:

D. B. Prentice, Director, Scientific Research Society of America.

G. D. Lobingier, Manager, Student Recruitment, Westinghouse Electric Corporation.

Eric Walker, Executive Secretary, Research and Development Board.

NOVEMBER 17, 1950

SOUTH AMERICAN ROOM, STATLER HOTEL

9:00 A.M. EMERGENCY ENGINEERING TRAINING PROGRAMS

Chairman: H. T. Heald, President, Illinois Institute of Technology.

10:30 A.M. UTILIZATION OF RESEARCH FACILITIES AND RESEARCH PERSONNEL

The Role of the Engineer in Community Affairs*

By MORRIS LLEWELLYN COOKE

Consulting Engineer in Management

These remarks have to do largely with the over-all education of an engineer as a man and a citizen, rather than with an examination of the curricula held to be appropriate for an engineering education. The proceedings of this Society suggest that the latter has been the target toward which your major efforts have been directed. So I may find myself in the wrong pew because what I have to suggest has a not too direct bearing on curricula. Our seeming failure as a profession to recognize the relationship between engineering and a wide range of public affairs, including politics, has, I believe, implications to which we will be well advised to give increasing thought.

While fully respecting the psychologist's idea of the unity of personality, education in a democracy must recognize three distinct areas of interest and development. The first has to do with us as private individuals and the development of character, the second with us as citizens, and the third with us as technicians —perhaps in the above sequence of importance. With engineers, the middle area, i.e., citizen status, is all but ignored. Voting at elections is admittedly hardly an adequate response to public as contrasted with private responsibilities. The net influence on the community of a single vote on a ballot carrying scores of unrecognized names may be nil or has, at best, a token effect.

In such a complex and constantly changing national and world order as we recognize at the present time, there can be no excuse for any individual's failing to carry a reasonable share of the total community load. This is especially true of professional men and women, those upon whom the best we have in education has been lavished. This "community load" does not consist entirely of what we too frequently deride as politics. Indeed, the bulk of it has either nothing at all to do with politics, or at best is indirectly related to politics. I have in mind all those myriad enterprises in which men and women come together to accomplish purposes for mutual and public, as contrasted with strictly individual, benefits. They may have social, cultural, or humanitarian objectives, or a combination of all three.

Dearth of Engineers in Community Service

Various methods have been utilized to establish statistically the failure of the engineer and scientist to participate in community affairs. One recent statement shows—with the agencies chosen quite at random—that there are no engineers or scientists to be found among the directors of the following organizations: the Indian Rights Association, the American Association for the United Nations, the Brandywine Valley Association, the Foreign Policy Association, or Collier's (magazine) committee for the annual award of its Congressional medals. Among those guiding the following agencies there appears only one engineer or one scientist in each case: the Institute of International Education, the national committee supporting President Hoover's

* Presented at a General Session of the 58th Annual Meeting of the ASEE, University of Washington, Seattle, Washington, June 21, 1950.

recent elaborate report on the reorganization of the Federal Government, Public Affairs Institute, the National Civil Liberties Union, and the Philadelphia World Affairs Council. In summary, among the 468 members of these groups three were engineers—William L. Batt, Charles Edison, and your author.

Then among 200 highest grade members of the major engineering societies living in a large eastern city, only four were reported by the local Community Chest to be associated with the management of its quasi-public social activities, such as hospitals, family welfare, symphonic music, housing, and homes for the aged and children. Among another 200, only two were associated with the annual welfare drive for the financial support of these institutions. Among over 300 scientists and engineers belonging to a distinguished social organization in the East, and one choosing a considerable part of its membership with great care from among technical groups, only five were found to be associated with social agencies.

An even more significant indication of our absorption in technical affairs is the fact that among over 40 organizations selected to aid our Government during the initial United Nations Conference at San Francisco, the State Department reported at the time that "scientific and engineering groups are totally absent." These groups comprised religious, educational, labor, legal, agricultural, racial, business, and social organizations, and the latter included Rotary, Kiwanis, and Lions. There was one engineer and one scientist, both regular employees of the State Department, among about 400 individual consultants and advisers officially chosen from among a wide variety of callings.

These figures, of course, do not invalidate the fact that there are many individual engineers who give unstintingly of their time to community causes entirely disassociated from engineering, or that there are engineering schools battling more or less successfully to develop social-mindedness in their students. But these statistics do strongly suggest that among several hundred thousand individuals in the U. S. A. educated in one way or another to practice engineering, only a negligible percentage interest themselves in public affairs.

Political Distaste Breeds Indifference and Isolation

We engineers seem to utilize our distaste for politics as an excuse for laying off on all types of community service. What we are prone to denounce as politics is of course only one phase of community life, even if it is one of the most important. Through its local, State, national and international constituent parts government—or politics—is the structure by which our whole civilization is supported. It is impossible to conceive of either science or engineering without this bedrock of human society. Without government there could be no engineering as we practice it. Do not let us fool ourselves. We do not in reality stand aloof from government, no matter how we try. On the contrary, the closer we can make the tie-in between government and engineering, the greater will be the profession's opportunity for service.

Our dislike for war does not keep us from accepting our respective assignments when war becomes a necessity. So our dislike for the ethically nether side of partisan politics is not a sufficient excuse for refraining, as most of us do, from all manner of community service. Because the attitude of indifference on the part of engineers toward public affairs is that of professional men generally, does not, it seems to me, provide an alibi. We engineers must build our own place in society. Qualifying as a reasonably good citizen will, of course, require only a fraction of the time, thought and energy which go into the making of a good engineer. So the frequently used excuse of lack of time has little validity. In a recent biography of Pasteur the author remarks, "He managed to remain faithful

to the laboratory while serving society," and later the author calls him "a fervent scientist and an effective citizen."

There are many ways in which an interested citizen may make his influence felt without entering the political arena or running for office. Jefferson cited as constituting the essence of a republic a synthesis of "action by the citizens in person in affairs within their reach and competence, and in all others, by representatives chosen immediately, and removable by themselves." Another authority has said, "There are, of course, fields in which the opinion of the expert must be sought. But in every democratic process we assume that certain primary decisions must be made by persons who are not specialists in the area concerned."[1]

It has always seemed to me a mistake to urge adult engineers to enter politics in view of the fact that few of them have had the seasoning fitting them for such an exacting and specialized calling. The best training for politics is in the less specialized give and take of the garden variety of community affairs, which it is the object of this paper to advocate. And in such matters we should mix as citizens rather than as engineers. In the primary discussion of community affairs there is no demand for men with professional training. Balanced and sympathetic judgment is wanted whether it comes from the high or low, from the formally educated or uneducated. In the councils of the people we do well to try to forget that we are engineers. If something comes up where our specialized training is useful, let us utilize the opportunity. But we should not wait to be called.

Granted that there is a quite limited number of engineers so equipped and conditioned as to be able to serve society well by holding public office, there is little warrant for the undiscriminating, and at times illiterate, attitude towards politics and politicians that is generally entertained by our group. If the profession of engineering is to play its full role in the new world already in formation, we must abandon what is now almost our universal hypercritical attitude towards government and the personnel and agencies through which it expresses itself. We are associated, of course, in this attitude by a large sector of the business world. We must learn neither to despise, nor to be afraid of politics and politicians, nor even to feel removed from this all important segment of our common life. This must never, of course, excuse being a party to the illicit or the venal. Nor should it act as a bar to rating critically the individuals in public service. But it does mean establishing at all levels an always available bridge of understanding and cooperation between engineering and politics, two great and constructive agencies of modern society. A great good both to the people at large and to our profession would be effected through such a seemingly logical readjustment of our relations with the political life of the nation.

The chasm that lies between the technicians and the Congress was illustrated both grimly and amusingly by a dinner which was held several years ago at the Commodore Hotel in New York City, attended by over 1,000 scientists at $10.00 a plate. The gathering was designed as a display of confidence in Dr. Edward U. Condon, head of the National Bureau of Standards, which it was expected would help him in his still unsettled controversy with the Un-American Activities Committee of the House of Representatives. The reaction of Congress was expressed the following day by a legislator who said, "The lodge had a very expensive meeting last night." There had been no doubt on the part of any Congressman as to Dr. Condon's having the complete confidence of his brother scientists. In the absence of any bridge or means of communication between the world of science and the Congress of the United States, in holding this dinner an alto-

[1] "Time for What?" by Howard H. Brinton, in "Human Events," September 14, 1949.

gether futile step was taken. As the Congressional Committee already knew the attitude of most scientists toward most politicians, the dinner was wholly without public significance.

Education For Public Service a Continuous Process

To carry out the dream of a great democratic state, which is the only possible long-time answer to totalitarianism in its various forms, will require that the ideal of public service be nurtured at every age—through earliest childhood, school and college days, and on through post-graduate and adult life. Is should be a continuous process of community service in action. And those who interest themselves in what can be done during the four or five years of a college engineering course, which is the theme of this paper, will be handicapped if the indoctrination has not been begun in family and school in pre-college days.

One of my earliest recollections has to do with my physician father's setting up in our backyard an official weather bureau station which required certain members of a family of eight, at appointed times and by turn, to make and record barometric and other observations. This was done solely to get members of the family interested in community activities, as was the practice of having the children choose, also by turn, a subject from the morning paper for general discussion at the midday meal.

It is cardinal to my thesis that for the great bulk of engineering and science students, the four-year college course represents all but a complete monastic withdrawal from community activities. Then comes graduation and with it a pseudo-professional status which makes generally impossible the doing of those things of lesser importance which goes with any *apprenticeship*—in this case an apprenticeship in citizenship. There follows a few years of preoccupation with earning a living and before long our engineer has established an almost complete detachment from the world of public affairs. No matter how high-minded and devoted one may be to a specialized calling, like engineering, without the touch that comes from a more or less intimate association with the unsegregated and organized life of the world around us, one's efficiency will be at a decided discount as a worker and consultant on public causes.

The very process of making a technician as generally practiced is narrowing and with most people needs to be offset by other worthwhile diversions, including relatively unimportant and not too absorbing community activities. Only so can we live down the enervating and often unwarranted prejudices which any ivory tower type of life builds up concerning types not quite like ourselves —union workers, for instance, and especially labor leaders, farmers, "foreigners" —perhaps those from a nearby county, various racial and religious types, politicians, and those generally less advantaged than ourselves. Actual participation in community activities enables one to reach common ground with men and women in different walks of life. It is learning by doing, as contrasted with studying or reading about public activities.

Avenues of Approach

Once it is decided to afford college students an opportunity to make a beginning on their lives as citizens, it must be admitted that little progress has been made in working out appropriate techniques. In a recent paper[2] of mine there were assembled some first few steps taken by those convinced of the necessity of widening the students' acquaintance

[2] "It's Time to Bridge the Technology-Political Chasm" by Morris L. Cooke in *American Engineer*, April, 1950. Also see "The Habit of Community Service" in *Mechanical Engineering*, December, 1947, "Science Knocks at the Door of American Politics" in *Mechanical Engineering*, September, 1945, and "Social Indifference in the Professions" in *American Engineer*, December, 1949.

with our modern and increasingly complex world—techniques for the most part lying quite outside the classroom. My correspondence suggests that there is considerable experimentation going on and that much material would be available to any intercollegiate agency set up to advance this phase of the education of an engineer.

For instance, through Dr. Gilbert E. Doan, Chairman of Lehigh's Educational Policy Committee, I have had a glance at an unreleased syllabus for a projected series of professional development conferences with detailed sections under such intriguing captions as "The Engineer and the College," "The Engineer and the Community," "The Engineer and Society," and others.

"These discussions," says Dr. Doan, "center around the student and his development to professional status—they begin with his individual self, where his interest is keenest, and lead him to examine his world and to prepare for professional leadership in it."

There is observable here and there among the colleges a tendency to experiment on a more comprehensive basis with student, and joint student and faculty, administration. These particular extracurricular activities seem to inspire new types of extra-mural interest. Douglas McGregor said recently, "To the extent that we can learn to operate our College democratically (and this means at Antioch the largest possible student participation) we can help to equip our students for effective citizenship in the modern world. We are humble about our accomplishments, but convinced that sincere experimentation along these lines by other educational institutions, and by human organizations of other kinds as well, is urgently needed to advance the democratic way of life. Only people who have learned responsible citizenship through actual experience can make democracy what it must become if our world is to survive."[3] It is not without significance that those colleges which have already done something actively to realize on this type of educational thinking are today planning new outlets for student community interest.

For the third year a group of 25 undergraduates recruited from Haverford and three neighboring institutions will work this summer in the Norristown Mental Hospital. The number of Haverford's participants in the Friends' foreign and domestic work camps will be increased. It is the general testimony that students taking a hand in this type of community activities have their social outlook altered and frequently modify plans for their lives in accordance therewith.

Haverford has one afternoon in the Fall when all classes are called off and most of the students volunteer to clean up the campus. Squads with a teacher and student as co-foremen cut down dead trees, rake leaves, paint grandstands, fill in gullies and such like. Faculty wives circulate with refreshments and first aid. This event affords a very easily grasped lesson in co-operative community housekeeping. At Stanford the students do similar cleaning up once a year in and about the convalescent building.

There are important lessons concerning the education of an engineer to be learned from a State-wide "Better Home Towns Development Plan" initiated six years ago by the Georgia Power Company with the objective, among others, of keeping Georgian young men and women from leaving the State. In answers to questions, many returned GI's placed unkempt hometowns as the No. 1 cause for dissatisfaction with Georgia as a place of residence. So as only one among many features in this imaginative social program, a $1,000 reward was offered to that town among over 500 with populations less than 1,000 which made the most varied progress during 1948. A simple cleaning-up was rated high in points to be considered. The results of this contest in hundreds of small towns were almost unbelievable.

[3] From *Antioch Notes*, April 15, 1950.

I mention two facts in connection with this plan which are pertinent to my thesis:

First: Before the plan was launched, 14 college-educated sales and engineering employes were chosen to have charge and then exposed during several weeks to a course of appropriate schooling, consisting of morning lectures on (1) sociology and psychology, (2) economics, and (3) municipal types of engineering. Then came talks by social workers. The afternoons were devoted to round-table discussions. Three of the fourteen "could not take it" and retired. Much of what was planned to be done throughout Georgia was actually quite remote from the normal professional field. The company reports that their difficulties were increased because the engineers put in charge had had no experience in community activities during their college days.

Second: The Georgia Power Company has made every effort to demonstrate the plan to the power companies in other states—together with its obvious and growing success. There have been engineering visitors galore. But to date the plan in anything near its totality has not been instituted elsewhere. The comment here is that those professional people who examined the scheme were so unfamiliar with normal community values, and so lacking in social-mindedness, as to be without adequate standards for judgment.

Evidence of the capacity of undergraduates to influence community affairs is indicated in a recent letter from a friend[4] associated with one of the leading law firms in my home city:

"In 1933 Pennsylvania was undergoing one of its periodic agitations for constitutional reform. To dramatize the need for this reform, to create an awareness of the pros and cons for a change in the organic law, an Intercollegiate Constitutional Convention was called. It was thought that alert, well-briefed students of political economy from the several colleges of our State could foregather at Harrisburg and, in a relatively short weekend, draft a model constitution for Pennsylvania. The Model Constitution was written. Ever since, the Intercollegiate Conference on Government, founded at the conclusion of that first Convention, meets once a year in Harrisburg, bringing together the youngsters from over fifty of our Pennsylvania colleges and universities to discuss their government.

"As to tangible benefits derived by these students from their participation, I could point out the number who have dedicated their lives to public service in the legislature, in government and social agencies and claim for the I.C.G. some of the credit. I could say that certain legislation might have been affected through the I.C.G. having dramatized the need. To me, however, the value of this foregathering of our young Pennsylvanians is as intangible—yet tangible—as freedom, as beauty. There are many communities of our State that are today better places in which to live because the Intercollegiate Conference on Government awakened in a student of a few years ago—a leading citizen of today—a civic consciousness, an awareness of responsibilities to his community far beyond that of paying taxes and shouldering arms; not a burden of residence, but a privilege of citizenship."

International Responsibilities

The seeming determination of the American people in favor of increased activities in the international field will exert a new influence on college faculties to develop greater social-mindedness on the part of their graduates and so better fit them for work in foreign parts. Both the State Department and ECA have experienced difficulty in recruiting technical staffs conditioned to react favorably in the situations normally encountered in foreign and especially in backward countries. The Friends (Quaker) Service Committee, operating in all parts of the

[4] John P. Bracken of Morgan, Lewis and Bockius.

world, recruits its staff from among those who are first of all humanitarians and then engineers or scientists, as the case may be. A noted college President stated in the late 30's that "Yale was sending forth men who knew thoroughly how to build bridges well, but had no conception of the social order for which they were building the bridges." If this was considered a disadvantage for engineers trained to practice their skills within the U. S. A., how much more serious the disability will be for those on foreign service.

There is general recognition of the need for setting aside normal practices in time of war, whatever the cost may be, if thereby our effectiveness can be heightened. As it becomes ever clearer that our cold war is almost the modern equivalent for a hot war, the same attitudes should apply. As one correspondent puts it, "A greater breadth of training for our students has been needed for a long time. Now thanks to the state of the world and the new destructive powers of science it is imperative."

My correspondence indicates that the college world is pretty well convinced that engineers must take more of a hand in the world of affairs lying entirely outside of our technical domain. Engineering *students* are our best prospects. The pedagogical problem seems to lie in the direction of doing something new while holding on tight to vital aspects of present practice, such as maintaining an ample work load on engineering students. The path ahead in this matter is not clear. But many first steps are reasonably obvious. These should be taken at once as the answer of engineering education to the oncoming grim, but inspiring challenge to our way of life. Deep waters for the American people undoubtedly lie ahead. We should go into this struggle singing but fully armored for the fray.

Report on Student-Faculty Evaluations*

By EDUCATIONAL METHODS DIVISION

Introduction

The Student-Faculty Evaluation Committee was established in April, 1949, to review the methods and purposes of the various programs that are used by students to evaluate the effectiveness of staff members as teachers. It was not the purpose of the committee to promote or discourage evaluation programs and the committee has tried to avoid "leading" questions that would tend to bias the replies.

The committee pursued its task by soliciting information concerning evaluation programs from deans of engineering and staff members in all schools where evaluations have been made. The information was solicited by means of a "check-sheet" questionnaire and a request for general comments. This report sums up briefly the manner in which the various programs are conducted and the faculty comments on the value and probable future of the programs.

Evaluation Procedure

Student-faculty evaluations have been used by a few schools on an informal basis for many years. Formal programs conducted on a semi-permanent basis were first developed in 1940. At the present time sixty schools have formal programs. Although a few of them are definitely permanent, most of them are being operated on a trial or probationary basis. Only ten per cent of these schools had such a program prior to 1946.

In most cases the program is conducted by a student organization in the following manner: During one of the regular class periods of every course section, near the end of each semester, the teacher excuses himself from the room and a member of the organization distributes evaluation sheets to the class. The students register their opinions of the teacher by placing check marks at appropriate places following descriptive statements. Space is also provided for the students' own written opinions or suggestions. The students do not sign their names but are asked to record their grade point average and the grade they expect to receive in the course. The sheets are then placed in an envelope and the envelope is sealed. It is retained in a convenient place until the end of the semester at which time it is turned over to the teacher for his information. In a few schools it is given instead to the administration (dean, department head, or personnel service bureau) to be used as a phase of administrator-faculty evaluation. The students themselves are not given any information regarding the results of the evaluation.

The Teacher

Teaching is a divine grace with which few people are happily endowed. Its ramifications are so numerous and so singularly significant that a true concept of the ideal entity often is lost. A few of the very many things that a distinguished teacher must *have* are (1) effectual academic training; (2) extensive experience in teaching and in professional work requiring the use of the material that he teaches; (3) a genuine interest in the welfare of the students (not

* Presented at a meeting of the Educational Methods Division at the Annual Meeting of the ASEE, Seattle, Washington, June 22, 1950.

the same thing as an interest in teaching —the motive may be different); (4) personal integrity; (5) social responsibility; (6) strength of character; and (7) teaching ability. Care must be exercised not to confuse any of the first six items with the seventh one. Academic training is sometimes misread as teaching ability—much to the detriment of the students. Teaching ability follows naturally from, and only from, a resplendent philosophy of education.

An exemplary list of the things that a good teacher must *do* would contain (1) transfer a large amount of factual information to the entire class; (2) give the students confidence in their ability to learn; (3) train the students to brush aside the superficial aspects of any controversy or problem and penetrate immediately to the central point; (4) improve the students' oral and written expressions by instruction and example; (5) develop the students' character and personality by the influence of close association in the classroom, office, community, and home.

Effective teaching is a "way of life" and a successful teacher who has resolved the various problems of his profession may well view a program by which students endeavor to evaluate his talents with some measure of justifiable doubt.

The Student

Whenever the patient judges the doctor he must base his judgment on apparent progress. The average student tends to give a high rating to a teacher under whom he ma good marks or one whose manner is cheerful and whose assignments are easy. Later he will often discover that a teacher whom he considered unpleasantly and unreasonably strict is the one who has given him his best preparation for professional life.

Most of the evaluation programs were conducted by student organizations (notably Tau Beta Pi) as a special activity, but it must be recognized that an organization cannot start an activity unless the majority of the student body is willing to participate. It has been suggested by a great many people that the programs have arisen because most of the students are mature service veterans who are critical of authority. Being cognizant of the current labor-management trends in the country they searched for and found a method of registering their ideas. The suggestion has considerable merit but only on the "maturity" count and not because the students are more critical of authority. Probably no one group of people is more critical of authority than another. The maturity of the students explains why they had the *courage* to establish evaluation programs but it does not explain why they *wanted* to start them.

Only a cursory analysis of the evaluation sheets is needed to discover that student-faculty evaluation is actually a protest against the faculty and not a desire to run the school as a special activity. The questions on the evaluation sheets are almost always expressions of "what's wrong with the teacher." On only three questionnaires were the students asked to suggest additional things that could have been done that would have helped them to learn more.

There is *no* justification for believing that the protestation is directed at any group of teachers such as young ones who are inexperienced, old ones who have not progressed, or "researchers" who consider teaching a secondary duty. Rather, there are many indications that it is a symptom of general discontent with the present teachers and their supposedly unrecognized faults.

The College

President Garfield's remark that a good college would be Mark Hopkins on one end of a log and a student on the other is perhaps the most hackneyed in the literature of American education. It is not often recalled that he also said, "I believe, then, that the two great supports of the College (Williams) are cheap bread and costly brains." In view of this state-

ment, it can be supposed that President Garfield would prefer to dispense with all deluxe buildings rather than allow the level of teaching to approach that which would require supervision by the students.

Every teacher is a good teacher or a poor one in his own way. One of the problems that each must solve in his own way is autocracy. A teacher must at all times be definitely in command of the situation, yet he should be able to enlist the willing and enthusiastic cooperation of all in his classes. Many colleges consider student-faculty evaluation programs as a desirable step toward democracy. Others feel that the end desired would be better approached by establishing seminars or discussion groups on teaching methods, and by encouraging exchange teaching with other departments and colleges.

The Future

Programs conducted by the students which attempt to evaluate teachers in a negative way with check-sheet questionnaires probably will not continue long. Programs that do not attempt to "evaluate" teachers but rather solicit constructive statements written by the students may survive indefinitely.

The committee regrets that it is unable to present a recommended program to be used for soliciting students' opinions. Additional study will be necessary before such a task can be undertaken.

By Harry W. Case
John W. Cell
Earl H. Flath
Edwin H. Gaylord
Pierre M. Honnell
George G. Lamb
W. B. Shepperd
Paul K. Hudson, *Chairman*
Student Faculty Evaluation Committee
Eric A. Walker, *Chairman*
Educational Methods Division

Summer Schools

The Executive Board has approved the following Summer Schools which will be held at Michigan State College either before or immediately after the Annual Meeting in June, 1950:

Engineering Drawing

Humanistic-Social Studies

Mechanical Engineering—Thermodynamics

Faculty Evaluation—A Report on the Faculty Viewpoint*

By G. G. LAMB

Professor of Chemical Engineering, Northwestern University

Student-Faculty Course Evaluation Procedures

Teacher-Course Evaluation Programs by students have been tried at many Universities over an extended period of years. Interest among students on many campuses has grown rapidly since 1945. The procedures used and the results obtained have varied from very unsatisfactory to very satisfactory.

The procedures used are as follows:

1) Student-paper editorials and articles appraising courses and teachers.
2) Student-published booklet giving detailed appraisal of courses, their teachers, etc., for guidance of new students.
3) General course evaluation questionnaires, results published in student paper.
4) Election of student representatives to handle all student complaints with administration.
5) General course evaluation questionnaires, handled by administration.
6) General course evaluation questionnaires, result to administration and teacher.
7) General course evaluation questionnaires, detailed results to individual teacher, anonymous correlation to administration and teachers.
8) General course evaluation questionnaires, results to individual teacher only.
9) Individual course evaluation questionnaires or class discussions for specific course administered by teacher.
10) General faculty opposition to all student course evaluation programs on basis of principle that a good teacher continuously studies his course, his students, and himself, so nothing is to be gained and valuable time and effort wasted by questionnaires of any sort.
11) General administrative opposition to all student course evaluation programs on basis of principle that administration and faculty continuously study courses, students, and faculty; and that it is unsound to permit students to infringe on the prerogatives of the administration.

Based on somewhat limited data available to the author, procedures 5, 6, 7, 8, 9, and 11 appear to have predominated in engineering colleges, while procedures 1, 2, 3, 4, and 10 appear to have been utilized in non-engineering colleges.

Faculty opinion ranges from active support to strong opposition to student-faculty evaluation programs. Most opinions appear based upon personal experience and sound judgment of the faculty member influenced primarily by procedure involved. Some faculty members are reported to be somewhat afraid of any such procedures by students, possibly due to insufficient experience with such matters. If careful attention is given to the details of procedure in handling such programs, it appears that the main reasons for the strong faculty opposition

* Presented at a meeting of the Educational Methods Division at the Annual Meeting of the ASEE, Seattle, Washington, June 22, 1950.

can be eliminated, although the question as to whether the time and effort involved in conducting such programs represents the optimum utilization of the faculty members' time may still be controversial.

Faculty Opinion Surveys

An opinion survey of forty-one faculty members attending the ASEE, Illinois-Indiana Section meeting on May 20, 1950, gave the following results:

1) Have you participated in student-faculty evaluation program? Yes, 81%.
2) Have you made significant changes in your teaching methods as a result of the evaluation program? Yes, 58%.
3) Do you think the average student is qualified to judge the effectiveness of the teacher? Yes, 30%, No, 17%, Some are, 53%.
4) Did you gain information that you could not have acquired by some other method, such as office conferences with the student? Yes, 71%.
5) Do you think that the student-faculty evaluation should be made a permanent program? Yes, 98%.
   a) At definite intervals? Yes, 51%.
   b) By individual instructors at any intervals they select? Yes, 47%.
6) Do you thing that the majority of the faculty considers the evaluation program important? Yes, 33%.
7) In you opinion, why was the student faculty evaluation program started? Due to student pressure—36%. Due to faculty interest—64%.

A similar opinion survey of seventeen faculty members at one institution that had tried procedure 7, above, gave similar results. (Seventy-five per cent stated that instruction was improved by evaluation program.)

To summarize the two faculty opinion surveys, it appears that:

1) The great majority (90%) of faculty members polled think that student-faculty evaluation should be made a permanent program, although nearly half believe it should be conducted by the individual instructors at any intervals they select.
2) A large majority (80%) state they gained information that they could not have acquired by some other method, such as office conferences with the student.
3) A large majority (80%) state the students are qualified to some extent to judge the effectiveness of the teacher.
4) About two-thirds reported they had made some significant changes in their teaching methods as a result of an evaluation program, although only one-third think the majority of the faculty considers the evaluation program important.
5) Several faculty members commented that the evaluation programs provide a better psychological atmosphere for learning by letting the students "blow-off steam" and by promoting better cooperation and understanding between students and faculty.
6) A typical faculty reaction is that his own rating is not quite as high as he thinks it should be, but that the summary of the ratings of his colleagues is higher than he thought. A typical student reaction is that dissenting students are more vocal than numerous.

Suggested Procedure for Student-Faculty Course Evaluation Program

Since the opinion among the faculties of engineering schools appears to be generally favorable to the establishment of student-faculty course evaluation programs, it is suggested that interested faculties consider the desirability of including the following items concerning procedure (cf. Procedure? 1st paragraph

1) A general questionnaire prepared by student-faculty committee applicable to all courses to assure the expression of student opinion on the following general areas:

a) Organization of the course
b) Presentation of the material
c) Testing and grading systems
d) Student-Teacher relations

2) Encouragement of faculty members to develop special course evaluation questionnaires or discussion periods for their own courses, to complement the general questionnaire.
3) A procedure that will not require excessive costs or work by the parties involved.
4) A procedure for transmitting the course evaluation questionnaire to the individual teacher with assured anonymity for students and faculty if desired by either.
5) A procedure utilizing code numbers known only to the individual faculty member whereby anonymous correlated information could be furnished to the faculty, to the chairman of the department, and to the dean of the school involved, with the view of aiding each individual teacher to do the best teaching possible.

Utilization of Questionnaire Results by Individual Faculty Member

As in most matters of life, what the individual gets out of such a program is proportional to the efforts he expends on it. Students opinion is, of course, only one of many factors the individual should consider in appraising his course effec tiveness, and most teachers will recall from their own experience changes in their own evaluation of course and teacher effectiveness made while an undergraduate and after a few years of experience in industry or in teaching.

A rapid appraisal will indicate the items of the questionnaire on which the individual is strong and weak. Several surveys have indicated that the typical college teacher is strong on "knowledge of subject matter" and relatively weak on "presentation." Considerable insight into methods of improving teaching effectiveness may be obtained by careful appraisal of all items on the questionnaires.

The main value of providing an anonymous correlation of results of all questionnaires is that it provides an objective basis for comparison by the individual of his effectiveness on any item with a distribution curve showing the effectiveness of all faculty members on each item, and therefore adds to motivation to increase efforts on those points most needing attention.

It is believed that it is the opinion of the majority of faculty members and of many college administrators that Student-Faculty Course Evaluation Programs will be most beneficial if conducted with assured anonymity for students and faculty, if desired by either. It would appear that the anonymous correlated results of all questionnaires would be of aid to administrators and faculty in determining the urgency of administration-faculty action to overcome weaknesses, but any such action should be carefully divorced from the Student-Faculty Course Evaluation Program unless the individual faculty member desires to discuss the results. It is assumed that engineering teachers entered the profession because they were interested in, and adapted to, it, with full recognition of the responsibilities involved. While few teachers will claim they have attained perfection in their calling, it is surely true that maximum performance will be attained by procedures that encourage individual self-development to the utmost.

A New Type of Course in Engineering Materials*

By JOSEPH MARIN and J. A. SAUER

Professors of Engineering Mechanics, Pennsylvania State College

Summary

In this paper, the authors review the existing practices of engineering schools in dealing with the general subject of engineering materials. It is noted that modern developments in engineering have made it necessary to consider more thoroughly the mechanical behavior of materials under widely varying types of stress, time, temperature and environmental conditions. It is, therefore, suggested that materials courses be made more technical and less descriptive, and that greater emphasis be placed on "mechanical properties," their determination, significance and use, and less emphasis be placed on "materials," as such. A possible outline of topics for a course designed along these lines is presented. A course—similar in all important respects to the one suggested—has been given in the Engineering Mechanics Department at The Pennsylvania State College for the last several years and has been found to be quite satisfactory.

Introduction

For many years, it has been standard practice in engineering colleges and schools throughout the country to require students to obtain a general knowledge of engineering materials. On the specific manner of acquisition of this knowledge, there has been no complete unanimity of opinion. Nevertheless, on the basic question of the importance and significance of this topic in engineering education, there has been general solidarity. For example, inspection of the engineering curricula in almost any college or university where engineering degrees are granted will reveal the inclusion of one or more courses in engineering materials.

The basic objective of most required course work in the general field of engineering materials might be stated as follows: to provide the student with sufficient understanding of the behavior and properties of materials, to insure intelligent selection and efficient and economical use. This is a broad objective and clearly not all aspects of the behavior of materials can be equally stressed or even considered in the limited time at our disposal. The question then arises as to which aspects of this subject shall be emphasized, which shall be de-emphasized, and which can be neglected entirely without severe loss to the student.

The answer to this question is a difficult one and cannot be made without consideration of the influence of recent advances in engineering and technology on the subject matter of materials. Some of the most important technological developments and their effect on material behavior and properties are:

(1) Increased speed of operation of machinery, requiring a more thorough consideration of dynamic and fatigue properties of materials.

(2) Higher temperature of operation of equipment—as in gas turbine, rocket and jet application—requiring a more thorough knowledge of creep behavior and of stress-strain behavior at high temperatures.

* Paper presented at the 58th Annual Meeting of the ASEE, June 1950, University of Washington, Seattle, Washington.

(3) Use of structural and machine members in which residual stresses have been intentionally introduced, requiring a knowledge of the behavior of materials in the plastic range.

(4) Advances in rolling, forming, and other fabrication procedures, requiring a knowledge of true stress-strain properties as well as plastic properties under various combinations of stress.

(5) Greater use of light weight materials in construction requiring a more thorough consideration of strength-weight ratios and buckling properties.

(6) Introduction of new materials, and new combinations of materials, requiring a re-examination of comparative mechanical properties, both from the point of view of fabrication requirements and of service requirements.

(7) Use of machines and products under greater extremes of environmental conditions, requiring a knowledge of effect on mechanical properties of low temperatures, high humidity, and corrosive atmospheres.

(8) Demands for greater safety and economy brought about by increased competition, failures of engineering constructions, and scarcity of critical materials, requiring competent stress-strain analysis together with efficient utilization of significant mechanical properties.

Most of the technological developments cited above, as well as other recent advances in engineering science and application, stress the need for more thorough knowledge of the mechanical behavior of materials and for closer union between theoretical stress analysis and the experimental study of mechanical properties. It is essential, therefore, that the future engineer be not only acquainted with the various properties of materials, their significance and use, but with the effect on these properties of other variables such as temperature, time, rate of loading, method of fabrication, etc. The experimental study of material properties should go hand-in-hand with the analytical study of stress-strain relationships and the necessity of both should be driven home by numerous simple type design problems.

Specific Nature of Existing-Type Materials Courses

It is now appropriate to examine existing-type materials courses in somewhat greater detail to see whether they meet the basic objective and the demands placed upon them by the various recent technological advances, some few of which have been discussed. Although no two collegiate institutions seem to have identical programs insofar as engineering materials are concerned, a common type of engineering materials course is a separate two or three hours per week general descriptive course covering most, if not all, aspects of engineering materials. In some institutions, the course in materials will precede the student's first course in Mechanics or Strength of Materials, in other institutions it will be given concurrently with this course, and in still other institutions it will be given along with the laboratory course in Testing of Materials. The title, too, varies from school to school, but wherever a separate course in Engineering Materials is given, it is usually known by that name or by "Materials of Construction," "Materials of Engineering," "Properties of Engineering Materials," etc. The text for the course is more often than not a well-known source book on engineering materials, such as Moore (1), Murphy (2), Young (3), Johnson (4), or Mills (5). While these books can and do serve a very useful purpose and represent excellent reference texts, they are usually far too comprehensive and voluminous from the standpoint of the detailed manufacture and fabrication of the various types of metals and alloys to have adequate space remaining for a thorough coverage of significant mechanical properties or of an adequate correlation with strength of materials or stress analysis.

In some schools, books such as Clapp and Clark (6), or Young (3) are used for courses where emphasis is on engi-

neering processes. Such courses, however, are usually special in nature and are not taken by all engineering students. In other schools, no courses in materials are required other than what is given in the standard one or two hour laboratory course in Testing of Materials. This is sometimes taught as a separate course and sometimes in conjunction with the Strength of Materials course. Here, such texts as Davis et al. (7), Gilkey (8), and Cowdrey and Adams (9) are usually used. These texts are usually written directly as laboratory manuals. They contain very little additional information on the determination and significance of mechanical properties under complex stress conditions, under widely varying temperature conditions, and under various types of dynamic load conditions.

Despite the differences from school to school, at most institutions where a separate course in materials is given, the course content will be somewhat as follows: chemistry and metallurgy of engineering materials; methods of manufacture and fabrication; physical and chemical properties and uses; ferrous materials, cast iron, wrought iron, steel; non-ferrous materials, aluminum, copper, nickel, zinc, etc.; wood and lumber products; cements and concrete; rock, stone and clay products; plastics, leather and rubber; protective coatings; testing and inspection of materials; materials specifications.

Since the course in Materials is usually but a 2 or 3 credit hour course, it is obvious that to cover completely the topics outlined above is all but impossible. Fifty years ago, the foregoing objection may not have been as valid as it is today. Since then, however, the development of many new materials, plus our increased knowledge of the chemistry and metallurgy of these materials, plus the great amount of additional data on the values of the physical properties of these materials, makes it impossible to satisfactorily treat all phases of engineering materials in one course. It appears to the authors that to cover adequately the subjects usually included in the single general type of materials course engineering schools would have to offer three separate and distinct types of courses. These courses would be: "The Processing of Materials," "The Chemistry and Metallurgy of Materials," and "The Mechanical Properties of Materials." They would be offered usually by Departments of Industrial or Mechanical Engineering, Chemical or Metallurgical Engineering, and Civil, Mechanical or Engineering Mechanics Departments, respectively. At the present time, some schools recognize this need and offer three such courses, but the engineering curriculum is so crowded that very few, if any, engineering students are able to schedule all three of these materials courses.

Aside from the time limitation on the presentation of the material usually offered in a general type engineering materials course, there would appear to be rather severe student limitations as well. With such a bewildering variety of topics to be presented, it is questionable whether students would acquire a mastery of all or even a thorough understanding of any one. Also, because of the non-analytical nature of the general descriptive-type materials course, the student has difficulty in remembering what he has heard in class or what he has read. In view of this, it appears to the authors and to some of their colleagues in the Engineering Mechanics Department at The Pennsylvania State College, that the time now spent in the standard type of materials courses can be more profitably utilized. We believe this can best be done by spent in the standard types of materials courses from the "materials" point of view to the "mechanical property" point of view. The materials part of the course must be drastically curtailed and even the part devoted to the discussion of properties of materials must be limited almost entirely to the so-called mechanical properties as distinct from the chemical or physical properties. However, the part of the course devoted to the determination, significance and usefulness of the

various mechanical properties must be enlarged and tied in much closer with the analytical course work of "Mechanics" or "Strength of Materials" and with concepts of simple design. In other words, the course must be narrowed but deepened and, by so doing, a much closer approach to our basic objectives will be realized.

Nature and Outline of Proposed Course in Materials

This brief discussion of the nature of existing courses indicates that too great emphasis is placed on "materials," as such, and not enough emphasis is given to the determination, significance and use of mechanical properties. The study of recent technological trends has emphasized also that the work on mechanical properties should be closely correlated with the analytical analysis of stress and strain on the one hand, and on the other, with the experimental determination of material behavior.

In view of the above study, the authors propose that the usual course in engineering materials be replaced by a course in "Mechanical Properties of Materials." In this course, a fundamental treatment is given of mechanical properties of materials, their importance and their significance. This is done by defining the mechanical properties of materials for conditions of static, fatigue, impact, creep loadings, high and low temperatures, and for simple and combined stresses and by stressing the usefulness of these concepts to the design of simple members and to their satisfactory performance throughout their anticipated life. Furthermore, in presenting the subject of mechanical properties, full use is made of the stress and strain relations for various types of stresses as treated in Strength of Materials. With Strength of Materials as a pre-requisite course, it is possible to show how the mechanical properties of materials are utilized in the design of machine, structural, and aircraft members. In this way, the student is better prepared to proceed with design courses.

It is recommended that the proposed course be a three or four semester hour course with one of these credits devoted to laboratory work. By determining in the laboratory the mechanical properties discussed in class, the student will acquire a better understanding of the meaning and significance of mechanical properties.

It is not proposed that all discussion of specific engineering materials be deleted. Rather, in the treatment of individual materials, it is suggested that emphasis be placed on the factors influencing the mechanical properties of these materials. For example, in the study of steel the effect of heat-treating and cold-working should be included both in the class and in the laboratory. Throughout the course, it is planned to have the student solve numerous problems dealing with the determination of mechanical properties under various types of loading conditions, and with the utilization of these properties in design of simple machine and structural members (10).

A suggested outline of topics for the new course is as follows:

TITLE: MECHANICAL PROPERTIES OF MATERIALS

1. INTRODUCTION
   - A. Objectives and Proposed Content
   - B. Effect of Recent Technological Advances
   - C. Need for Continued Experimental and Theoretical Research
   - D. Significance and Utilization of Mechanical Properties

2. MECHANICAL PROPERTIES—STATIC LOADING
   - A. Simple Stresses
     - (a) Tension — Nominal and True, Stress and Strain Relations
     - (b) Torsion—Stress-Strain Relations
     - (c) Bending-Stress-Strain Relations
   - B. Combined Stresses
     - (a) Theories of Failure
     - (b) Plastic Stress-Strain Relations
     - (c) Stress Concentrations
   - C. Hardness

3. MECHANICAL PROPERTIES—DYNAMIC LOADING

A. Fatigue
  (a) Tension and Compression—Completely Reversed Stress
  (b) Torsion and Bending—Completely Reversed Stress
  (c) Effect of Range of Stress
  (d) Stress Concentration

B. Impact
  (a) Notched Bar Tests
  (b) Energy Considerations
  (c) Stress-Strain Relations
  (d) Influence of Rate of Loading

C. Damping Capacity
  (a) Methods of Measurement
  (b) Effect of Stress and Other Variables

4. MECHANICAL PROPERTIES—TIME EFFECTS

A. Creep
  (a) Mechanism of Creep
  (b) Deformation-Time Relations
  (c) Creep Rate-Time Relations
  (d) Creep-Rupture Relations

B. Deterioration
  (a) Effect of Atmosphere
  (b) Effect of Aging
  (c) Effect of Humidity

5. MECHANICAL PROPERTIES—TEMPERATURE EFFECTS

A. High Temperature
  (a) Effect on Strength
  (b) Effect on Ductility
  (c) Effect on Other Mechanical Properties

B. Low Temperatures.
  (a) Effect on Strength
  (b) Effect on Ductility
  (c) Effect on Other Mechanical Properties

6. MECHANICAL PROPERTIES—FERROUS METALS AND ALLOYS

A. Factors Affecting Mechanical Properties
  (a) Chemical Constitution
  (b) Heat Treating
  (c) Mechanical Working

B. Significant Properties
  (a) Tensile and Compressive Strength
  (b) Ductility and Stiffness
  (c) Resistance to Corrosion
  (d) Availability and Economy

7. MECHANICAL PROPERTIES—NON-FERROUS METALS AND ALLOYS

A. Aluminum and its Alloys
  (a) Strength and Strength-Weight Ratio
  (b) Corrosion Resistance
  (c) Formability and Ductility
  (d) Availability and Cost

B. Other Non-Ferrous Materials
  (a) Copper
  (b) Zinc
  (c) Nickel
  (d) Alloys

8. MECHANICAL PROPERTIES—NON-METALLIC MATERIALS

A. Wood and Forest Products
B. Plastics
C. Concrete and Cementing Products
D. Stone and Clay Products

Under each topic, the student is assigned simple design problems illustrating the use of the particular mechanical properties being discussed at the time. In a three semester hour course, it will probably be found that two-thirds or more of the semester is required to cover the first five topics; i.e., that part of the course not dealing directly with specific materials.† This leaves at most one-third of the time to discuss individual materials, their significant mechanical properties and their availability and cost. With the limited time available, only very brief consideration can be given to such topics as the manufacture, processing, metallurgy and chemistry of the materials.

It should be pointed out that some institutions have already made considerable progress in rearranging their former general materials course along the lines noted above. For example, a course, similar to that described except that it contains a total of 3 credits instead of 4, has been in operation in the Engineering Mechanics Department of the School of Engineering of The Pennsylvania State College for the last several years. As might be expected, there have been a number of changes of course content made from

† This, at least, has been our experience at Penn State.

year to year. Nevertheless, the staff is in agreement that the present course is a considerable improvement over the general, descriptive style course. The students, too, have reacted favorably and seem definitely to prefer the more analytical, less descriptive approach even though they have had considerably more to do in the way of problems and home assignments.

REFERENCES

1. H. F. MOORE, "Materials of Engineering," McGraw-Hill Book Company.
2. G. MURPHY, "Properties of Engineering Materials," International Textbook Company.
3. J. F. YOUNG, "Materials and Processes," J. Wiley & Sons, Inc
4. J. B. JOHNSON, "Materials of Construction," J. Wiley & Sons, Inc.
5. A. B. MILLS, "Materials of Construction," J. Wiley & Sons, Inc.
6. W. H. CLAPP AND D. S. CLARK, "Engineering Materials and Processes," International Textbook Company.
7. H. E. DAVID, G. E. TROXELL AND C. T. WISKOCIL, "The Testing and Inspection of Engineering Materials," McGraw-Hill Book Company.
8. H. J. GILKEY, G. MURPHY, E. O. BERGMAN, "Materials Testing," McGraw-Hill Book Company.
9. J. H. COWDREY AND R. G. ADAMS, "Materials Testing," J. Wiley & Sons, Inc.
10. J. MARIN, "Mechanical Properties of of Materials and Design," McGraw-Hill Book Company.

College Notes

Case Institute of Technology announced the appointment of Dr. Elmer Hutchisson as acting president to serve during the leave of absence granted to President T. Keith Glennan to enable him to accept the appointment as a member of the Atomic Energy Commission. Dr. Hutchisson's appointment is effective October 1. He will continue in his position as dean of the faculty and director of research and of the graduate division.

The first step in an instructional program emphasizing nuclear power has been taken by **Columbia University's School of Engineering** with the establishment of a new course in "Nuclear Power Reactor Technology." The course is for qualified graduate students of engineering, mathematics and the sciences. Dean John R. Dunning said the School would probably offer additional new courses in the near future. Several of the science departments, particularly physics, will also participate in the program.

Lowell W. Herron, assistant to the president at **Clarkson College**, has been named Dean of the Faculty, it was announced by President Jess H. Davis. The change in designation of Mr. Herron's office is part of the administrative reorganization at Clarkson which included the simultaneous naming of William J. Farrisee as Dean of the College.

Eric Walker, of **Pennsylvania State College**, has been appointed Executive Secretary of the **Research and Development Board** in Washington, D. C.

Roman Smoluchowski, Professor of Metallurgical Engineering at **Carnegie Institute of Technology**, has been appointed a consultant to the **Research and Development Board.**

Jet Propulsion—A Chemical Engineering Elective for Senior and Graduate Students

By ROBERT A. COOLEY

Associate Professor of Physical Chemistry, University of Missouri School of Mines and Metallurgy

An outline of a one semester two hour per week course in the chemical engineering aspects of jet propulsion is presented. The course effectively reviews and extends principles of physics, chemistry, metallurgy, ceramics and engineering while providing an introduction to a rapidly developing field of engineering of considerable interest for its practical and scientific uses. The relative novelty of the subject, current newspaper and newsreel attention, plus many satisfying but not too advanced theoretical analyses of jet propulsion phenomena work together to maintain a high level of student interest. The chemical engineer's and the chemist's appropriate interest in this field is clearly demonstrated.

Introduction

Announcements such as (a) 62 ton Boeing XB47 Stratojet spans the United States in less than 4 hours at a velocity of over 600 miles per hour, (b) Military requests 200 million dollars from Congress for 3000 mile rocket range, (c) Secretary of Defense announces that United States has an "Earth Satellite Vehicle" program, and (d) Engineering data now exists for construction of Los Angeles to New York passenger carrying rocket, are powerful stimulants for the technically inclined imagination as well as that of the news commentator. Jet propulsion with its unique features in the field of propulsion has not been put away with the mothball fleet but is becoming possibly more important as an area for engineering development than it was in wartime. The basic principles of jet propulsion are easily learned; but what is being done to develop the engineering knowledge needed to reduce these principles to broader practice? Many engineering educators were not able to evaluate jet propulsion with confidence and realism during the war due to secrecy. Now the public has access to many developments achieved with public funds.

Each university has to decide whether to include specific courses in jet propulsion in its curriculum and which if any of its engineering divisions, aeronautical, mechanical or chemical, should offer courses. Although a few[1] courses of unrestricted military security have been offered in jet propulsion, an increasing number of engineering schools may be expected to offer courses in jet propulsion. Courses were given for military personnel during the war[2] at educational

[1] See texts for courses written by authors from Purdue University, University of California, Ohio State University and University of Michigan: a. Principles of Jet Propulsion and Gas Turbines, M. J. Zucrow, Wiley, 1947; b. Rocket Propulsion Elements, G. P. Sutton, Wiley, 1949; c. Introduction to Gas Turbine and Jet Propulsion Design, C. A. Norman and R. H. Zimmerman, Harper Bros., 1948; and d. Theory and Design of Gas Turbines and Jet Engines, E. T. Vincent, McGraw-Hill, 1950.

[2] Malina, Frank J. "Jet Propulsion—Its Effect Upon Engineering Education," Pacific Southwest Section of Society for Promotion of Engineering Education at University of California, Feb. 22, 1946.

TABLE I—OUTLINE

CHEMICAL ENGINEERING ASPECTS OF JET PROPULSION

I. History and Current Status
   A. Technical Progress Chronologically
   B. Analysis of a Modern Large Scale Engineering Effort to Develop Jet Propulsion (OSRD* methods and results)

II. Fundamentals of Jet Action
   A. Newton's Laws
   B. Momentum
   C. Basic Principles of Rockets and Nozzles
      1. Maximum velocity of a rocket
      2. Nozzle theory
      3. Thrust of a rocket
      4. Specific impulse
      5. Efficiency of a rocket motor
      6. Burning law for solid propellants
      7. Effect of temperature on burning of propellants

III. Morphology of Jet Propulsion Devices

IV. Combustion in Jet Propulsion Devices
   A. Thermodynamics
      1. Energy release
         a. Frozen equilibrium
         b. Shifting equilibrium
      2. Flame temperatures
      3. Methods of calculation
      4. Applications of spectroscopy
      5. Comparison of JP combustion problems with other combustion problems
   B. Chemical Kinetics
      1. Theory
      2. Experimental results
   C. Engineering Applications of Thermodynamics and Kinetics
      1. Internal ballistics of solid propellant rockets
      2. Internal ballistics of liquid propellant rockets
   D. Heat Transfer
      1. Theory
      2. Results

V. The Rocket
   A. Operation of Liquid Propellant Rockets
      1. Hydraulics
      2. Ignition
      3. Cooling combustion chamber and nozzle
   B. Operation of Solid Propellant Rockets
   C. Performance
   D. Design

VI. The Ramjet
   A. Principles of Operation
   B. Diffuser
   C. Combustion Chamber
   D. Nozzle
   E. Performance

VII. The Pulsejet
   A. Principles of Operation
   B. Performance

VIII. The Turbojet
   A. Principles of Operation
   B. Ram and Mechanical Compression
   C. Turbine
   D. Performance

IX. The Turboprop
   A. Principles of Operation
   B. Performance

X. The Testing of Jet Propulsion Devices
   A. Types of Tests
   B. Instrumentation Installations and Problems

XI. Chemistry of Propellants
   A. Storage Stability
   B. Chemical and Physical Properties
   C. Theoretical Predictions
   D. Composite Chemical Evaluation of Propellant Systems

XII. Manufacture of Rocket Propellant
   A. Raw Materials
      1. Nitroglycerin
      2. Nitrocellulose
      3. Liquid oxygen
      4. Liquid hydrogen
      5. Liquid fluorine
      6. Hydrogen peroxide
      7. Hydrazine
      8. Aniline
      9. Nitric acid
   B. Unit Operations
      1. Mixing
      2. Drying
      3. Extruding
      4. Machining
      5. Inhibiting

XIII. High Temperature Resistant Materials
   A. Metal Alloys
   B. Ceramics

XIV. Economics of Jet Propulsion

XV. Current Examples of Jet Propulsion Devices

* Office of Scientific Research and Development.

institutions. At the request of the Army Air Forces Professor Th. von Karman in 1944 at the California Institute of Technology initiated a graduate course in jet propulsion for training officer personnel. This course required a year and involved the study of such subjects as aerothermodynamics, chemistry of jet propulsion, high temperature materials, rockets, thermal jet propulsion systems, and applications of jet propulsion systems.

Since exploitation of the principles of jet propulsion for military purposes during the war was carried out by physicists, chemists, chemical engineers, aeronautical engineers, mechanical engineers, metallurgists, civil engineers, mathematicians, astronomers and others, few strong prejudices have yet arisen as to what kind of training is most valuable for young jet propulsion research and development workers. The type of worker most in demand is the one who has abilities and attitudes that tend to fit him for the much discussed title of research engineer—one with keen engineering judgment and sensitive acuteness to the implications of scientific research results.

The part of jet propulsion concerned with the theoretical prediction and practical evaluation of propellants, combustion, and ignition phenomena offers the chemist or chemical engineer a challenging task which can utilize his fundamental training efficiently. Design of combustion chambers and propellant handling equipment and material selection problems can also be assigned to chemical engineers, although engineers of different training (mechanical, metallurgical, aeronautic, ceramics) may be preferable in some cases. Jet propulsion development centers may prefer to train young technical graduates in jet propulsion after they have received their basic training in universities, but an appreciable number of students may find it worthwhile to elect an introductory course in jet propulsion.

The establishment at the California Institute of Technology and at Princeton University (through funds of the Guggenheim Foundation) of two National Centers for the Study of Rockets and Jet Propulsion indicates the academic interest in the non-military study of the fundamentals of rockets and jet propulsion. These centers would seem to provide excellent locations to carry out unclassified research and instruction on jet propulsion. They are highly desirable in view of the purely scientific interest in jet propulsion per se and as a scientific tool separate and distinct from commercial or military applications. Other schools which offer at least an introductory course in jet propulsion should provide a natural feeder system for the centers.

A jet propulsion course (Outline—Table I) as presented at the University of Missouri School of Mines and Metallurgy is offered by the Chemical Engineering Department and requires two class hours each week for an 18 week semester. Prerequisites for the course are senior or graduate standing in chemical engineering, chemistry, metallurgy or ceramics. The course is an elective one and appeals to some students as an introduction to a well advertised and imagination stimulating field of engineering in which they feel that most things humanly possible may not be completed before they start the course.

Conclusions

As the outline indicates jet propulsion is replete with instances in which rather satisfactory predictions may be made with the knowledge a senior engineering student has acquired. Thermodynamics, hydraulics, and strength of materials appear much more interesting and worth mastering to a student who not only considers these subjects in the class room, but also sees and hears their results in the newspapers and movie newsreels. The student is required to design completely a solid or liquid propellant rocket with reasonable specifications before the course is completed.

Although the course introduces new material, it presents an excellent opportunity to review briefly and extend, with particular aims in view, principles of physics, physical chemistry, chemical engineering, metallurgy and ceramics. Presentation of testing methods introduces opportunities to discuss electronic recording of pressures, temperatures and mass flows under very rapidly changing conditions. A rather detailed study of the design features of a German V-2 rocket is included.

There is little difficulty in finding sufficient open literature for the course. Since 1940 there have been more than a thousand articles (exclusive of newspapers) and thirty-six books on jet power plants and gas turbines published.

College Notes

Albert Kingsbury Hall, the **University of New Hampshire's** new million-dollar home for its College of Technology, was dedicated in a two-day ceremony on October 13 and 14. The largest of more than 45 major classroom and dormitory buildings on campus, it is named for the University's first professor of mechanical engineering who served from 1889 to 1899. A symposium developed around the theme "Technology in the Service of Mankind" featured the first day of the celebration.

The appointment of L. F. Stutzman as Chairman of the Department of Chemical Engineering in the Technological Institute of **Northwestern University** was announced. Professor Stutzman succeeds V. C. Williams who resigned to accept a position as Chief Engineer of the General Anilin and Film Corporation. Miklos Hetenyi, Professor of Mechanical Engineering at **Northwestern University** has been appointed to the first Walter P. Murphy Professorship of the Technological Institute.

THE COOPERATIVE DIVISION

will hold a

Mid-Winter Meeting

at

The University of Florida

Gainesville, Fla. ***January 9 and 10, 1951***

Industrial Growth and Formal Engineering Training*

By FRED T. AGTHE

Process Engineer, Allis Chalmers Company, Milwaukee, Wisconsin

Within recent years so much attention has been given to subjects that pertain to industrial growth and formal engineering training, that one may discuss them only in an atmosphere of caution and diffidence. Those of us of an earlier generation recall the attitude of a large part of American industry toward the employment of the college graduate of that period. In industrial fields, the college or university graduate was not too popular or in urgent demand—he was forced to demonstrate his ability and usefulness in the shop, railroad, or the mine, before he was considered of sufficient value to his employer to warrant receiving an adequate living wage.

During the period to which I refer, a man whether college trained or not, was appraised largely on the merits of his ability. The modern trend is a departure from this concept, for mass action pressure groups, believe that life is too short and too evanescent to waste time on crucial time-consuming tests, and that people trained for certain activities by formal methods should reap, before it is too late, the fruits that are there for the picking.

I am not trying to be facetious, for I am convinced that much of what is done today in the many activities of our complex society is carried on with an utter disregard for intrinsic values and the relative merit of things. Perhaps it is due to abject ignorance, both religious and secular, of the principles upon which real and lasting values are based, and in that respect our elaborate system of universal education has been weighed in the balance and has been found wanting.

Despite these somewhat dismal comments on the condition of our times, the training of able young men for a career in the field of engineering is a vitally important activity. I can think of nothing of greater value to our nation than an educational institution endowed with great teachers who are men of character, and whose lives are devoted to the training and inspirational guidance of young men in a line of work for which they are best fitted.

Trends in Education

Returning a little closer to the subject of this address, it is apparent without further comment that the demand made by American industry on colleges and universities for young engineers is representative of our times, and the old order of past generations will not return. Educational institutions and industry alike, therefore, now face the realities of a situation that is here to stay. It becomes necessary for both groups to be introspective and to examine themselves, the situations, and trends so that they may be formed and developed into a new pattern that will redound to the best interests of all.

There appears to be no diminution in the growth of the activities of applied science. Even now new agencies are at work in Governmental departments and in large industrial organizations in studies

* Presented before the North Midwest Section of the ASEE, State University of Iowa, November 5, 1949.

of the use of atomic energy for power generation, for therapeutics, and other activities that are important to the progress and well-being of the nation. There seems, therefore, to be no limit to the expansion of engineering development per se, and unless the social system should collapse completely, there should be an ever-increasing need for men who are thoroughly trained for these greatly augmented activities.

Recent discussions conducted in the meetings of this Society and published in *The Journal of Engineering Education* convey the thought that educators are giving earnest consideration to the increasing demand for highly specialized, technically trained people. Many of us who are employed in industry also have long realized that there are places of technical employment in the modern plant that do not require complete conventional engineering training, and that specific training of a terminal nature would be sufficient in preparing for full employment at adequate compensation. The so-called technical institute no doubt will be developed in the future to train many technicians for jobs in American industry that are now filled by college-trained young men who have received a Bachelor of Science degree in some branch of engineering.

The growth and development of the Technical Institute in larger industrial centers should meet these needs of modern industry. Thus accredited colleges that teach engineering should be relieved of the pressure of rapidly increasing enrollment, and would be able to devote more time to the teaching of the basic sciences—the fundamental engineering subjects—and to conducting the socio-humanistic courses that are now regarded as necessary for the broad education of engineers of the future.

The growth and development of applied science have taken place so rapidly, that their full impact on colleges of engineering has not been fully realized. Like most great movements leading to change, the vital factors were at first not apparent. World War II accelerated the development, and the over-crowding of engineering colleges brought to focus the dilemma toward which engineering training was drifting.

The committee on Relations With Industry, organized and conducted so ably by the late Dr. A. R. Stevenson, has devoted its efforts to the study of problems that are common to industry and the college. Its activities have become so widespread, and have been considered of such importance, that the committee has become a division of ASEE, which is an indication that constructive work has been attempted and will be continued by a greater number of the members of the Society.

Engineering is the Nation's third largest profession, and is growing rapidly. It has been estimated that jobs in engineering may increase by as many as 100,000 within the next twelve years to a total of approximately 450,000. In order to train men for the technical skills that are needed to keep abreast of these developments, a serious appraisal must be made of formal engineering training. This may indicate the necessity of separating the field into two parts, one for the training of technicians and one for the training of technologists.

In the report published by the Committee of Undergraduate Curricula in *The Journal of Engineering Education* for September 1949, pertinent suggestions are made that pertain to the future development of formal engineering education. Under the caption "Principles Which Should Guide the Development of an Undergraduate Program in Engineering," the Committee concedes that the four years spent in undergraduate work is long enough for a sound engineering course in which the fundamentals are taught thoroughly.

It would seem obvious that with the great growth of technology in all of its branches, the formal training at a university can include only the fundamentals of engineering. This would be true even though the course was longer than four

years. Thus it would be up to the student to round out his training for the work in which he will be engaged either by postgraduate work, or by enrollment in a graduate training course conducted by industry.

In analyzing this suggestion, it must be recognized that there is a dividing line in all engineering activities beyond which a high degree of formal training in basic science is necessary, and below which concrete practical instruction, based upon the rudiments of scientific principles, will suffice. Such training would fall within the category of the instruction that is available in the technical institute or the school or terminal technical education.

In Milwaukee, over the past four years, there has been established a committee known as the University Cooperating Committee of the Wisconsin Society of Professional Engineers. This committee was formed at the suggestion of the University of Wisconsin. It was believed that the Committee might be able to obtain the concerted opinion of the engineers of the State regarding the trends in engineering development and the changes required of enginering colleges to meet them. The Committee, composed of some leading industrialists and engineers employed in private and State activities, has met conscientiously over the years and has worked in harmonious collaboration with the faculty of the Engineering College of the University of Wisconsin. In addition to the many other subjects that have been discussed, there has been given considerable attention to terminal technical education. In order to clarify the position that the Committee has taken, I shall take the liberty to quote in part, the recommendations that have been made concerning terminal technical engineering training.

RECOMMENDATIONS

"1. The Committee believes that there is a distinct need for the technical institute graduate who is a trained technician in some specialized field. Such men will assist professional engineers in design, experimental and production work in industry.

"2. The Committee believes that the training of such men should be given in technical institutes which are provided with the proper faculty and equipment. It should not be an auxiliary course to apprentice training but should be a separate and distinct curriculum. The technical institutes preferably should be located where the particular specialty or specialties taught can be utilized in nearby industry. No attempt should be made to teach all specialties in each technical institute or even in any one school.

"3. The Committee believes that publicly supported technical institutes can best be organized and administered by the State Board of Vocational and Adult Education. Because of the present existence of vocational schools in most industrial sections of the State, it would be possible to teach the various specialties where there is a need for them in that locality.

"4. The Committee believes that the technical institute courses should require a maximum of two years' time and should be specialized and terminal in nature, as training for a specific job in industry. The large majority of its graduates would enter industry on completion of their courses. A relatively few individual graduates may for some reason wish to continue with a university engineering course. It is recognized that the technical institute's personnel, texts, and course contents will be quite different from those of engineering colleges. Therefore, it is not possible to give equal or even definite partial university credit for technical institute work. The accreditation should be on an individual basis where transfer to the College of Engineering is requested.

"5. The Committee believes that the technical institute course should not be over two years in length and all attempts to expand it into a longer course or to make it equivalent to the University College of Engineering should be discouraged."

The late Dr. W. E. Wickenden, when President of the Case School of Applied Science, is reported to have said, "Engineering is an art and a profession upon which we depend for our prosperity in peace and for our survival in war. It is based partly upon science; but chiefly

upon personal qualities, technological judgment, wisdom and enterprise of its professional members, and upon the skill, experience and reliability of its craftsmen." It is to this larger craftsmen group in the development of formal technical training that one must give serious consideration. To that definition I would add the skill, experience and reliability of its *technicians* and craftsmen.

There seems to be more clearly defined than ever, a line of demarcation between technician and the technologist. It is true that the consideration of the technical institute in our scheme of technical training will have a salutory effect upon engineering training in all its branches. The technical institute, its progress and development should and must be guided with an open mind. Those who bear that responsibility will face opposition; and there are many factors involved that present problems which will be difficult to solve. Whatever may be the outcome, a serious responsibility rests upon educators, industrialists and engineers alike. The solution should and must be found in the intelligent and vigorous establishment of improvements in formal engineering training that lie within the framework of our democratic society. Whatever changes are made must conform with the basic principles of the American way of life.

REFERENCES

1. *The Journal of Engineering Education*, Volume 40, No. 1, September 1949, page 39.
2. *Mining Engineering* for October 1949, page 43. *American Institute of Mining and Metallurgical Engineers.*
3. "Mineral Engineering Education of the Future in the Light of Present Day Research Problems." Presented by F. T. Agthe at the Annual Meeting, Mineral Industry Education Division, American Institute of Mining and Metallurgical Engineers, University of California, Berkeley, California February 13, 1949.

A Possible Technique for Determining the Relationship Between Certain National Indices and the Demand for Engineers

By W. P. WALLACE, H. W. CASE, and L. M. K. BOELTER *

At the national ASEE meeting held in Austin, Texas, in 1948, one of the authors presented a short report showing the relationship existing between the indices of industrial fuel (gas and electric power) consumed by industry in the State of California and the number of engineers graduating from engineering colleges. This relationship was shown graphically by means of increases or decreases in yearly percentage, using 1935 as a common base. That a relationship might exist with this index of industrial size and the number of engineering graduates, as well as the number of members belonging to societies, seemed indicated from the similarity of the curves which were developed.

As a result of these tentative indications, it was deemed advisable to explore a number of known national indices, using these indices as variables to attempt to determine if any relationship existed between them and the number of engineering graduates obtaining employment in the engineering field. If a relationship could be established between this variable and an index or indices, it might be possible to develop eventually a method of utilizing the index or indices to predict the number of engineers who would be hired for a given year. Since the number of engineering graduates hired by industry for engineering positions has not been compiled on a yearly basis, it seemed desirable to test the hypothesis by attempting to predict (1) the number of members belonging to the engineering societies, (2) the number of engineers registered in the various states, and (3) the number of neophyte engineers graduating from the engineering schools through the method of determining the inter-relationship existing between them and other national indices used as variables. One of the major difficulties in an investigation of this nature is that the various indices show considerable variability in the length of time in which they have been compiled. This factor has necessitated the restriction of this study to the period extending from 1929 to 1948. The indices as they are compiled nationally are not directly comparable; therefore, in order to make the data comparable, they were converted into percentages of increase or decrease, using 1935 as a common point. For the purposes of this experimental study the following indices were used as variables:

1. Society membership
2. Retail store sales
3. Total energy
4. Wholesale price index
5. National income
6. Production index
7. Dow Jones averages
8. Consumer price index
9. Government non-war spending
10. Engineering graduates
11. Registered engineers

The first step in the analysis consisted of plotting the actual percentages of increase or decrease from 1929 to 1948

* University of California, Department of Engineering, Los Angeles.

TABLE 1

RAW DATA

Year	Society Members (1)	Retail Store Sales (2)	Total Energy (3)	Wholesale Price Index (3)	National Income (2)	Production Index (3)	Dow-Jones Ave (2)	Consumer's Price Index (3)	Govt. Non war Exp (3)	Engr Grad (4)	Regist Engrs (5)
1929	117	124	126	119	129	126	244	124	33	67	38
1930	118	127	112	108	121	104	193	122	38	66	50
1931	120	117	97	91	113	86	109	111	49	79	65
1932	119	95	83	81	91	67	55	99	73	92	81
1933	105	91	90	83	85	79	66	94	61	97	91
1934	100	93	95	94	91	86	82	98	91	103	95
1935	100	100	100	100	100	100	100	100	100	100	100
1936	103	116	113	101	113	118	138	101	122	97	107
1937	108	120	121	108	120	130	130	105	107	98	114
1938	114	118	105	98	120	102	108	103	100	100	129
1939	119	132	114	97	132	125	116	101	121	114	149
1940	125	144	127	98	146	143	110	103	111	130	162
1941	131	156	137	109	169	175	100	107	93	131	167
1942	137	143	117	124	195	228	89	119	90	138	172
1943	143	149	154	129	227	274	111	126	76	132	177
1944	148	163	166	130	247	270	120	128	93	116	182
1945	157	177	163	132	214	233	145	131	131	73	187
1946	169	202	160	151	208	195	158	143	208	99	202
1947	183	187	178	191	185	215	155	163	206	181	253
1948	200	183	182	206	190	220	158	174	228	258	294

All data expressed as a percentage of the item of 1935 = 100%

using 1935 to represent one hundred per cent. The result was a formidable array of curves yielding little or no information as to relationship that might possibly exist between the variables. Similarly, due to this same high degree of variability, it was impossible to determine whether any one or more combinations of the variables might predict better than other possible combinations.

In order to measure the existing relationships it was decided to ascertain the inter-correlations existing between the variables (Table 1), and to subject these inter-correlations to a factoring technique to discover whether certain combinations of the variables could be used to formulate a regression equation for the purpose of prediction. It should be noted at this point that the authors are fully aware of the dangers and pitfalls that exist in the artifacts that are often encountered in applying the correlation technique to small samples. Therefore, since it was impossible to get time series data beyond 1929 for many of the indices, and while they recognized these dangers in using small amounts of data, it seemed advisable to explore the possibilities of this method of approach.

Utilizing the factoring technique developed by Gengerelli (6) a multiple correlation of .96 for society members is reported when the significant independent variables were shown by the factoring to be: consumer price index, national income, and government non-war spending. For the engineering graduates a .77 coefficient of correlation existed when the significant variables were found to be the wholesale price index, and government non-war spending. A 1.00 correlation coefficient was obtained between the registered engineers and the significant variables of government non-war spending, national income, and engineering graduates. The indices which were found to give the highest multiple correlations with each of the variables being solved for, were then used in a regression equation (6) according to their indicated factor loadings as shown by means of the factor analysis. The regression equation was then used to determine the predicted relationships year by year from 1929 to 1948. The actual and predicted relationships are shown in Figs. 1, 2, and 3. The very magnitude of the correlation coefficients, and the close correspondence between the

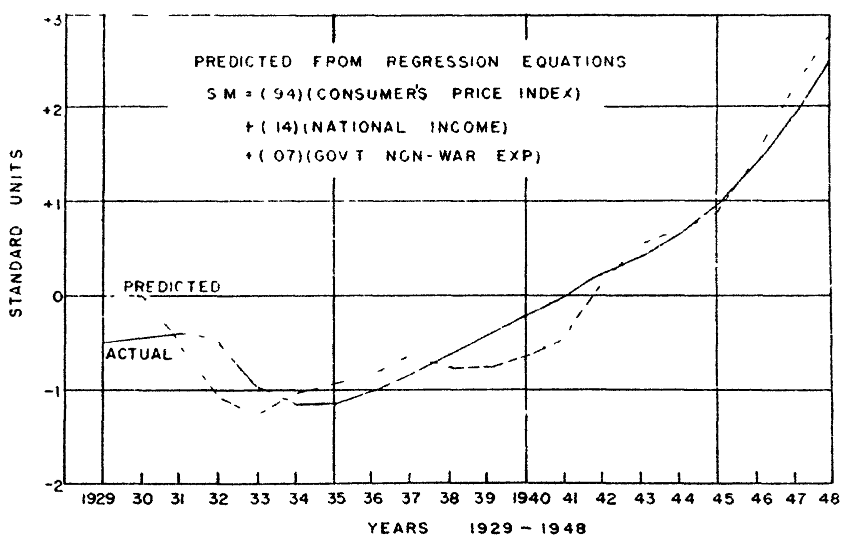


FIG. 1. Societies memberships—actual and predicted.

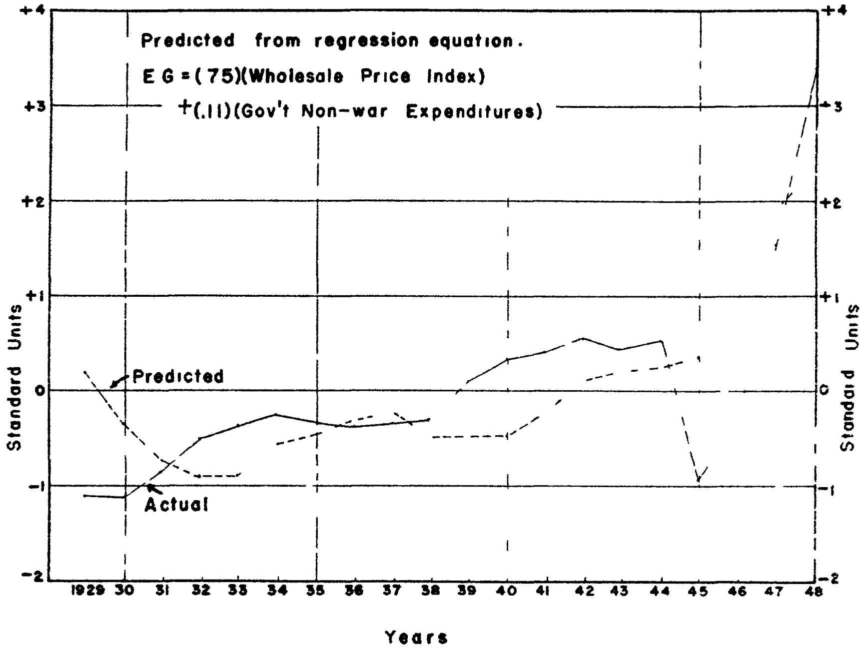


FIG 2 Engineeiing graduates—actual and predicted.

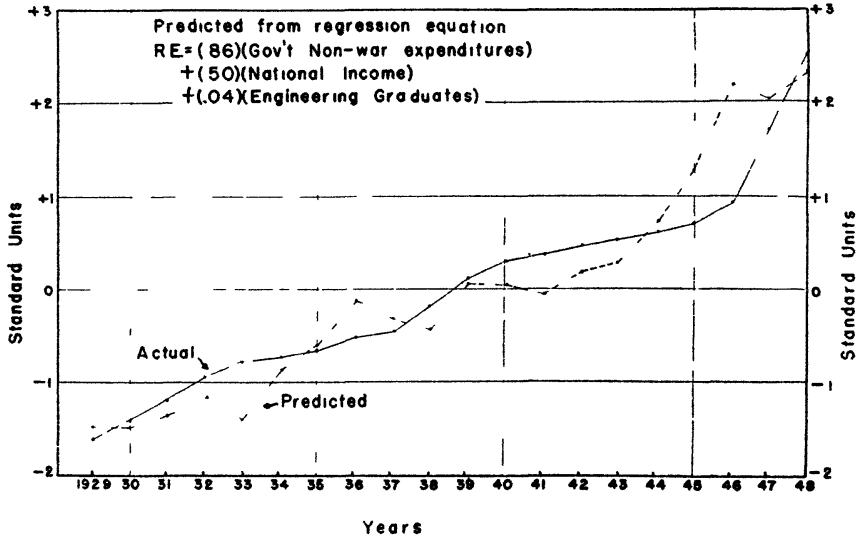


FIG. 3. Registered engineers—actual and predicted.

TABLE 2

Correlation Coefficients

	Retail Store Sale	Total Energy	Whole sale Price Index	National Income	Production Index	Dow Jones Ave	Con Price Index	Gov't N W Exp	Eng Grad	Reg Eng
Society Members	91	90	95	76	7	31	94	7	70	87
Retail Store Sales		93	83	86	81	42	83	72	50	82
Total Energy			89	91	92	4	85	66	61	8
Wholesale Price Index				65	76	47	97	78	75	82
National Income					47	24	66	27	5	73
Production Index						21	67	44	44	76
Dow Jones Averages							54		−04	02
Consumer's Price Index								68	64	75
Gov't Non War Exp									7	86
Engineering Grad										82

$$r = \frac{[n\, \Sigma XY] - [\Sigma X\, \Sigma Y]}{[n\, \Sigma X^2 - (\Sigma X)^2]^{\frac{1}{2}}[n\, \Sigma Y^2 - (\Sigma Y)^2]^{\frac{1}{2}}}$$

TABLE 3

Significant Variables in Standard Units

Year	Wholesale Price Index	National Income	Consumer's Price Index	Gov't Non War Exp	Eng Grad	Regist Engr	Society Member
1929	05	−43	28	−1 40	−1 09	−1 59	−51
1930	−30	−58	19	−1 30	−1 12	−1 40	−47
1931	−83	−74	−33	1 09	−81	−1 17	−40
1932	−1 14	−1 17	−89	−63	−51	−93	−44
1933	−1 07	−1 29	−1 12	−86	−39	−77	−95
1934	−73	−1 17	−93	−29	−25	71	−1 13
1935	−55	−99	−84	−11	−32	−63	−1 13
1936	−51	−74	−79	31	−39	−52	−1 02
1937	−30	−60	−61	02	−36	−41	−84
1938	−61	−60	−70	−11	−32	−18	−62
1939	−64	−37	−79	29	12	13	−44
1940	−61	−10	−70	10	39	33	−22
1941	−26	35	−51	−25	41	41	0
1942	20	86	05	−31	58	18	22
1943	36	1 48	37	−57	44	56	44
1944	39	1 87	47	−25	59	64	62
1945	45	1 81	61	48	−95	72	95
1946	1 04	1 11	1 17	1 95	−34	95	1 39
1947	2 29	66	2 10	1 92	1 59	1 74	1 90
1948	2 76	76	2 62	2 34	3 40	2 37	2 52

Above data calculated by using

$$Z = \frac{X_i - \bar{X}}{\sigma_{X_i}}, \quad \sigma_{X_i} = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n}}$$

TABLE 4

ACTUAL AND PREDICTED SCORES

Year	Society Members		Engr. Graduates		Registered Engrs.	
	Actual	Predicted	Actual	Predicted	Actual	Predicted
1929	−.51	.05	−1.09	.19	−1.59	−1.46
1930	−.47	.01	−1.12	−.36	−1.40	−1.45
1931	−.40	−.49	−.81	−.71	−1.17	−1.34
1932	−.44	−1.04	−.51	−.92	−.93	−1.15
1933	−.95	−1.29	−.39	−.90	−.77	−1.40
1934	−1.13	−1.05	−.25	−.58	−.71	−.84
1935	−1.13	−.94	−.32	−.42	−.63	−.60
1936	−1.02	−.86	−.39	−.35	−.52	−.12
1937	−.84	−.65	−.36	−.22	−.41	−.30
1938	−.62	−.75	−.32	−.47	−.18	−.41
1939	−.44	−.79	.12	−.45	.13	.07
1940	−.22	−.66	.39	−.44	.33	.05
1941	0	−.45	.41	−.23	.41	−.02
1942	.22	.13	.58	.12	.48	.19
1943	.44	.52	.44	.21	.56	.27
1944	.62	.68	.59	.26	.64	74
1945	.95	.85	−.95	.39	.72	1.28
1946	1.39	1.40	−.34	1.00	.95	2.22
1947	1.90	2.19	1.59	1.93	1.74	2.04
1948	2.52	2.73	3.40	2.33	2.37	2.53
σ =	.30		.69		.40	
R =	.96		.77		1.00	

Above predicted scores calculated from the following regression equations:

Society Members = (.94)(Consumer's Price Index) + (.14)(National Income) + (.07)(Government Non-War Expenditures)

Engineering Graduates = (.75)(Wholesale Price Index) + (.11)(Government Non-War Expenditures)

Registered Engineers = (.86)(Government Non-War Expenditures) + (.50)(National Income) + (.04)(Engineering Graduates)

predicted and actual, warrants a further exploration of the possibility of developing this technique in such manner that the significant independent variables for predicting the number of engineers to be hired can be isolated.

If this possibility is to be explored further, it will be necessary to sample a representative group of industries to determine the number of engineers who have been added to their total personal complement for each specific year covering the period for which the various indices are available.

REFERENCES

1. Private communications from the New York offices of ASME, AIME, AIEE, ASCE, and AICHE.
2. Handbook of Basic Economic Statistics, Government Statistics Bureau.
3. Minerals Year Book and Weekly Coal Report, Bureau of Mines.
4. JOURNAL OF ENGINEERING EDUCATION.
5. National Council of State Boards of Engineering Examiners, 1948–1949.
6. "A Simplified Method for Approximating Multiple Regression Coefficients." J. A. Gengerelli, *Psychometrika*, September, 1948.

Painting and the Graphic Arts*

By STEFAN HIRSCH
Chairman, Art Division, Bard College

The fine arts and engineering may seem at first glance to be apart. One bridge between them, however, is certainly architecture. Although architecture may not be, as has been claimed, the mother of the arts, it is an art, and engineering, even before it was called engineering, has had much to do with it. Indeed some of the best pieces of modern architecture were done by engineers alone, without any pretensions to being "artists" or even architects.

Engineering and Art

As I have never had any working connection with an engineering school, you will have to forgive me for some involuntary over- or under-statements. But I have known quite a number of engineers. Naturally I have known many artists. The mutual contempt in which they hold each other would be quite shocking were we not conscious of the contemporary dichotomy between the sciences and the arts. Allow me for the moment to commit that unpardonable sin: to think of the engineer as an artist. The artist is the man who has the sometimes dangerous ability to sense new meanings in the relationships between man and man, man and nature, man and his ideas, man and art. Can you find any fault in my applying this description at least to the ideal engineer, or even to the physical scientist?

Now to be a man who can perform such revaluation of old relationships in the social, the natural, the ideal, or the artistic spheres, requires imagination. And imagination is as surely the property of every human being as is the intellect. Both can be fashioned into highly acute tools of action. I regret to say that our schools do not concern themselves much with this. Since Descartes, the training of the intellect toward skepticism has tended to destroy the operative unison of imagination and intellect. I am not speaking against Cartesian skepsis in scientific or even philosophic endeavor. I am merely decrying the foolishness of its application to those other fields of human striving, which more rigorously involve the emotional endowments. If you are with me in this, then we have to postulate the development of the imagination, along with that of the intellect of anyone whose work can be identified as an art, irrespective of what scientific tools or disciplines it may employ. The scientific fraternity, I am afraid, has lost the know-how of fostering the imagination during several centuries of naturalism, materialism, positivism. But despite the inroads these philosophies have made even into art education, especially through the art historians, there are still a few artists left, who as teachers understand the problem, and know how to deal with it.

The Cultural Vacuum

Let me get back to the engineers I have met, many of them during our frequent and long sojourns in Latin America. The majority seem to be almost invariably uncultured, socially unhappy people, with time and tequila heavy on their hands, and despised by the population. If they speak Spanish at all, which most of them

* Presented at conference of the English and Humanities Division of the New England Section of the American Society for Engineering Education, Yale University, October 8, 1949.

do not really, even after years in residence, they have failed to learn about those people with whom they work, their politics, their mores, sensibilities and ideals. They never appear to realize how much Latin-American culture is suffused with artistic and other extra-scientific and non-commercial passions, and in the manner of most Americans they choose to disregard it as sissy stuff, never establishing any mutual understanding. British engineers, surprisingly, do much better. But then their humanistic education is infinitely superior to that of our boys.

This is not really surprising. Most of our engineering students go from a humanistically inadequate high school training to a four-year course of highly specialized and humanistically retrenched engineering training, to enter the profession directly. I say "training," because education in the sense of learning how to deal with underlying principles and ideas, except in the mathematical sphere, comes to them not through their curriculum, but only through the accidental presence of a natural-born great teacher. While they master, in a sense, the techniques which represent the fruits of occidental thinking since those proto-scientist-artists Alberti and Leonardo, they have only the vaguest notions of the philosophic and social dilemmas which beset the paths of this thinking, dilemmas which still vex our contemporary scene. In almost all other fields of higher learning it has been found necessary to give the young intellectual workers more than a glimpse of all this. I grant you that, if our high schools were better, we could probably dispense with a few years of higher education. But they are not, and therefore we cannot.

To return for a moment to the Latin American scene: an American artist, residing there for a while, is almost invariably well-treated even if he doesn't speak the language, providing he doesn't go after the girls in too unapproved a fashion. Why is that? I would recommend to you to read the chapter on "The Rich Culture of Mexico" in *The Meeting of East and West* by F. S. C. Northrop, Professor of Philosophy and Law at this very University. It makes amply clear why to the Latin American the artist is *ipso facto* a human being, and the scientist-engineer only if he proves it.

But even within our own gates, the anti-intellectual tenor and the artistically atrophied character of American life, which favors the highly specialized, humanistically telescope training of the technician, makes itself felt in wasteful conflict. On most campuses, hostility between the scientist and the humanist is often but thinly veiled. The philosophers are frequently chosen as mouth-pieces for one side or the other, when they should be the very ones to resolve the conflict. The psychologists lead a schizophrenic life, because they cannot make up their minds where they belong. Even the historians find it difficult. Is this good for the education of our youth? I think not!

By now, I hope I have made some case for more intensive teaching of the humanities, and of the arts as part of them, without having to discuss further the spiritual devastation, brought about in this country, by our obsessive emphasis on the practical, the mechanical, and the inevitably fatal. I would just make this other point: that any person of real vitality, who is allowed to develop only one pole of his field of energy, is only half a man. And it would seem that in this country, and in the coming epoch, we will desperately need whole men, with coördinated intellects and imaginations, in politics, in the sciences, and in the arts. I am, therefore, not even an advocate of the art schools. I would have art taught in colleges, universities, yes, and in engineering schools, because most art schools err precisely in the same direction. They do not attempt to make whole men of their students but technicians and followers of fashions. They do not develop their critical faculties, their understanding of the scientific component of their environment, nor their individual position on the flight-lines of their historical perspective. Like engineers, they are apt

to become narrow specialists. Unlike engineers, the material reward for their narrowness is usually a pittance, and their social influence makes itself felt less widely. Just because the engineer, in more ways than one, is in a key position in the formation of our culture, we would like to see him masterful and whole.

Art for Instruction Engineers

I will now attempt to show how the plastic arts could be introduced. If the study of art should become required, and I do not think that it should, there ought to be a choice of several arts open to the student whose curriculum is otherwise fairly iron-clad. Literature should be there, not only in the guise of English as a tool for the writing of reports; painting, sculpture, and the graphic arts, not purely as decoration or polite pornography; music not just out of an amplifier, as background noise for boring studies or for not-so-boring love-making. They should be offered as sources of enjoyment, as playgrounds for the imagination, as wells of understanding of oneself, of others, of historical periods and of the ideas in other cultures.

I know this sounds fanciful and unrealistic. Yet, it seems to me that many of the feats of engineering sounded much more so when they first appeared in the form of literary or graphic dreams. Cowardice has rarely been the vice of engineers or artists. Just the same, I will abandon this sweeping little dream of mine and speak only of the less inclusive one of painting taught in engineering schools as a matter of course and clear purpose.

Now, contrary to the understanding of science, a sense of art is a highly individual thing, a personal possession, unique to a certain degree in every single case. It is usually there quite amply in childhood, on a subconscious level, when good and evil are not yet clearly distinguished, and before our moral, social, and commercial conventions have corrupted this artistic essence. We must then ascertain with each student, what of this sense of art has remained, to what degree it has been buried under provincial garbage and "corn," and where to let the student start shovelling. How can we do this?

If I were to organize a course in painting at an engineering school, assuming that at least two semesters were available, I would institute one weekly two- or three-hour session for each group of no more than 15 students. They would meet in a well-lighted and not too horrible-looking studio, equipped with the usual paraphernalia and also with a battery of filing cabinets, well-stocked with moderate-sized color reproductions of works of art from the cavemen to Picasso and beyond.

There would be no lectures! Students would start to paint anything they wish: some of the objects around; objects they have brought themselves; things from memory or imagination; things, people, landscapes, ornaments, abstractions, dream symbols; in short, anything their fancy turns to. And of course in any medium they choose, even in pencil. Speaking of pencils—engineering students must be fed to the teeth with them. They could forget them for a while in this course, forget security to go out on adventure. Moreover, drawing may be basic, but it is not elementary to painting; painting is the elementary discipline of painting. Draftsmanship will be developed through it by and by. So will perspective, anatomy and all the other blandishments of tradition, if indeed they be needed. It is like the case of calculus, which is one of the basic disciplines of engineering. I don't believe it is given anywhere as an elementary math course. Too difficult? Well, drawing is equally too difficult when the imagination is to be stimulated and let loose again for the first time in 15 years.

Remember: we are not trying to produce great draftsmen or even painters but imaginative engineers. Still, whoever insists on pencils, those great little tools of abstraction, may have them. No doctrinaire inhibitions! Whatever little flight of the imagination, it must be done on the student's own wings.

Criticism of the work should consist, not in telling the student what is wrong, but in making him tell us. When he arrives at that point, we select from the cabinets a master's painting which deals more or less with the same problem as the student's job. Again, there should be no lecture, but a guided discussion helping the student to see the analogy. This may be followed by certain technical suggestions, if possible some alternative procedure, which would give him the responsibility of choice, with or without thought. He'll learn soon enough to think and to imagine, before acting.

The second session of the course would be entirely devoted to critical and historical work on the basis of the study of reproductions and of assigned readings. There would be no lectures and no textbooks, but discussions and an adequate choice of pertinent books in the library. Not a survey course in the history of art, skimming over the surface of chronological facts and appearances, it would be work in depth. Remember? We don't want to train art critics. We want to cultivate the imagination of engineers. They would first learn conscientiously to observe paintings, all of each painting. They would not be encouraged to blow off steam about their likes and dislikes, indicating only their own previous state of servitude and nothing about the picture. Close study will soon reveal to them their own capacity to feel things more deeply than at first glance. Or as Schopenhauer put it rather neatly: "Before a work of art you should act as though you were in front of royalty; you don't speak until you are spoken to; or else you might just hear the braying of an ass." Gradually they would be induced to think about the interrelated form and content of works of art, to read about them and to write down what they have observed, felt, and read.

The studio sessions would alternate, weekly, with the critical seminars. In these workshops the student's artistic endowments would be explored by him and by the instructor, and developed in the most individualistic mode possible. Since great talent cannot be expected of the average student, we would not stress too much the professional perfection of his artistic accomplishments while grading his work. Instead more attention should be paid to the artistic insights he has gained, the adaptations of technical proficiency to creative aims, no matter how simple. It is impossible to describe meaningfully the further growth of this part of the course because it must concern itself with individual cases in which anything can happen, from the dead level of convention to little miracles.

The critical studies which can be rated along more established lines would progress from the discussion of individual masterpieces to comparison of works with similar subject matter, but by artists of different periods. This would slowly clarify the historical fact that man's protean poetic imagination implements him equally with protean technical imagination, and that each culture, each epoch, each group and each individual leaves behind art products whose forms reveal the general content of the feeling and thought of those who made them. Reading would be assigned to illuminate not only the esthetic considerations, but the cultural backgrounds in the broadest sense. Finally a definite period of art could be studied, applying all the techniques of investigation previously learned, to afford a glimpse into the dynamics of history and the vastness of man's aspirations. From the art historian's point of view this might appear a superficial course. But we don't want to train art historians. We want to open a window on Parnassus for engineers.

I could now continue to finer points, talk about the therapeutic values of art because of its ability to create from dream and play elements something which is socially communicable and therefore eminently practical, and things of that sort. But, ladies and gentlemen, there is nothing of immediate practicability in this plan, except that an engineer, sensitive to

human values, while not therefore a better technologist, is apt to be a better specimen to let loose on other humans. There can be no guarantee of greater earning power for the engineer who happens to know that one of the greatest artists of our time and hemisphere, Orozco, died a few weeks ago; or who understands that Picasso is neither insane nor a fake; or why Michael Angelo could not have been a member in good standing of the Lions' Club. But in almost all parts of the world, people care to do business not necessarily with the man whose price is the lowest, but with a man they like. And they like people who understand their modes of living and who appreciate things beyond the job and the dollar.

To understand a work of art requires a mixture of uncompromising alertness and self-respecting humility. To create a work of art, more than almost any other academic discipline demands direct action, after clear-cut decision, based on intellectual as well as emotional motivations. In other words, it involves the whole personality and requires from it what we demand of the good citizen: Heart, Wisdom, Devotion. If these are not the qualities you want to see even in engineers, don't let them study art.

Sections and Branches

The annual meeting of the **Michigan Section** was held on May 20, 1950 at Wayne University in Detroit. Speakers at the meeting included the President of Wayne University, D. D. Henry, L. G. Miller, A. R. Carr and A. R. Hellwarth, who spoke on "The Employment Opportunities for Engineers in Small Businesses." The following slate of candidates for officers was presented and unanimously accepted: Chairman, H. M. Dent; Vice-Chairman, W. P. Godfrey; Secretary-Treasurer, F. L. Schwartz; Representative on General Council, L. G. Miller.

The **National Capital Area Section** held its meeting on May 6, 1950 at the University of Maryland. H. H. Armsby, Vice President of the ASEE presided. The program included a discussion on "The Improvement of Engineering Teaching." Officers elected included: Chairman, R. B. Allen; Vice-Chairman, W. Oncken; Secretary-Treasurer, L. K. Downing; Representative on the General Council, R. S. Glasgow.

The sixteenth annual meeting of the **Southeastern Section** took place at Roanoke and Blacksburg, Virginia with the Virginia Polytechnic Institute as host on April 20, 21, 22, 1950. E. B. Norris introduced L. F. Livingston, of E. I. du Pont de Nemours and Company, who addressed the group on "Progress in Better Living." Other speakers included T. C. Brown, M. I. Mantell, D. H. Pletta, L. R. Quarles, J. D. Fuller, F. C. Vilbrandt, A. T. Granger, W. F. Gray, J. H. Sams, and F. J. Lewis. The following officers were elected: Chairman, E. B. Norris; Vice-Chairman, R. L. Sumwalt; Secretary-Treasurer, B. Bayer; Representative on the General Council, C. R. Vail.

Music and Engineers*

By KLAUS LIEPMANN

Assistant Professor and Director of Music, Massachusetts Institute of Technology

Our concern this afternoon is with the future scientists and engineers whose interest in music is greater than can usually be satisfied during their study years. The notion that music is more or less a queer, merely emotional, effeminate, or, as some people say, purely sensual preoccupation for a few gifted people—a specialty for "musical" students only, whatever the word "musical" means—that notion needs revision. One has only to remember that many great scientists, mathematicians, medical men are ardent and active music lovers. These men are used to substantial and prolonged concentration and to the combination of physical and spiritual values. Any recreation which would consist of hazy daydreaming would never interest them for any length of time.

Music is a language expressing human thoughts, human aspirations, fears, and hopes through the Ages in organized and concentrated form. You may call it a combination of imagination and higher mathematics. Because it is universally and eternally human, it is a language open to everyone and all. To say, "I don't like music," is as senseless as saying, "I don't like trees." To say, "I don't understand music," is no more than admitting, "I cannot follow the groping of science for the mysteries of the universe." Being puzzled by music need not be more alarming than being involved in the endless search for an explanation of man's behavior, his actions, and his ideas about the state of life and death.

The only trouble with this language of music is that it cannot be translated. An artist chooses his own medium, and if the message contained in a piece of music could be better or more convincingly expressed in a painting or in poetry, the composer would not say what he has to say in music. There are, of course, basic similarities in the main thoughts and problems presented during any particular period of history by its fine arts, its music, its literature, its philosophy. To a certain degree the art of the Renaissance will throw light on its music, and vice versa. These correlations, however, will serve no better than a simile, for eventually the art of music has to be dealt with on its own terms, that is, with the stuff, the logic, the impact of music itself.

Music and the Humanities

Now if we can agree on the importance of music as a link in the chain of the humanities, as a thing in itself, and ever-present throughout History, there remains the question how to keep music alive and strong in our engineering institutions. I believe that there are three avenues open, at least to engineering schools, and the problem is constantly to improve "traffic" on these avenues.

I should put as first in importance the creation of a musical environment. I believe that a technological school should include among its books the serious biographies of the great composers, music encyclopedias, histories of music, together with books of English literature, history, fine arts, fiction, etc. I would avoid the purchase of popularized books on music or composers. The chatty type of writers

* Given at the conference of the English and Humanities Division of the New England Section of the American Society for Engineering Education, Yale University, October 8, 1949.

on music, trained in women's clubs lectures and the suave radio commentators have driven away scores of potential music lovers rather than brought them nearer to music.

I also think that opportunities to listen to records in a quiet room should be made available to students. A comprehensive record library requires, of course, considerable money, space and personnel. A beginning can always be made, however, in acquiring a basic record library which will in a short time contain representative works of the literature of music, including samples of all types of music: Folk-music, songs and Lieder, chamber-music, symphonic works, choral works, opera.

Of great help to the phonograph listener will be the availability of pocket-size full scores for chambermusic and symphonic works, and of piano scores for songs and operas. Even for those who cannot follow a score (and very few really can) occasional attempts in that direction will help to convey the structure of the music heard. Music has the disadvantage from the point of view of the analyst or serious student in that it does not stand still, but flows on at its own tempo. Repeated hearing helps in grasping more details and the over-all structure. Yet still better is the study of the blueprint of a piece of music before and while hearing it. A score is the musical equivalent of an architectural blueprint and, like an amateur architect, a student of music can make out certain features from the score.

Finally, in creating a musical environment I would suggest arrangements for more or less formal concerts of *live* music in the school itself. No matter how many occasions the city or town may offer for attending outside concerts, a string quartet, a good singer, or instrumentalist, or one of the small traveling opera companies offered by the school in its auditorium or lecture hall convince students more than anything else that broad cultural interests including music are needed in order to become a good scientist or engineer, or administrator, or architect, and that a technological school practices what it preaches along these lines.

Music as Recreation

Extracurricular activities are the second avenue of approach towards music for the engineer. You would never believe how much enthusiasm, talent and skill exists among young Americans, especially among those whose mental curiosity and searching minds drive them to study science and engineering, until you have given them ample opportunities to make music in their free time. Of all students at least ten per cent (and unfailingly this group recruits itself from the fifteen per cent with the best all around marks) bring a remarkable training in the singing and playing of music to their secondary school. It is felt that a college or university should at least do what every high school of the country does—provide musical instruments for band and orchestra, and furnish sheet music, rehearsal rooms, pianos, and professional "coaches" for music. Too often I have heard it said that "there is so little time for extracurricular music that a little fun and enthusiastic, if incompetent, leadership is all that is needed here."

I think, rather, that one should argue like this: "Just because our students do not get enough of the humanities in their curriculum, the extracurricular activities must be considered an important educational factor. Therefore, in order to make the best use of the little available time, and also because these students are used to experts in aerodynamics, etc. let's get a specialist in music if we want to give them music at all."

Incidentally, the recreational aspect of extracurricular music is frequently sadly neglected because one assumes that fun and recreation are incompatible with concentration and hard work. While it is granted that athletic activities, demanding the last ounce of energy from the participants, are healthful; and that concentration in playing chess, and sweat in building a boat or a cabin are fun—in

music one frequently takes dabbling in Gilbert and Sullivan or reclining on a couch and reading a magazine while listening to the radio or phonograph for the happiest state of enjoyment and recreation. I would rather claim that the straining of one's concentration and energy in singing Bach Cantatas or Handel's *Messiah* or the integration of many orchestra players in giving a creditable performance of Beethoven's early symphonies is the healthiest mental and physical recreational occupation for those whose studies and professional training tend towards scientific specialization.

It should not be forgotten that it is an important social boost for engineering students to be able to join liberal arts girls' colleges in singing and playing the world's greatest choral and orchestral music. The greatest benefit, however, to be derived from hard work in preparing concerts lies, I believe, in the fact that students "rub shoulders" with great men when they prepare a program of classical or contemporary music. They become intimately acquainted with the thoughts and feelings of the masters when they try to conquer their music, and will truly appreciate a professional interpretation ever after.

Curricular Arrangements

Finally, I think there should be a place for music in the curriculum of a technological school. While I know that there are other engineering schools which offer courses in music, I am only familiar with the situation at M. I. T. Therefore, I will tell you about the music course there. In the curriculum of a Technology student there is only a limited time left for the humanities, approximately one fifth of his total curriculum hours. The first year will usually be devoted to English. The second year might include history, the third year social sciences with perhaps a choice in the second semester of psychology, labor relations, or industrial economics. Finally, in the senior year there is time for electives: international relations, history of ideas, books and men, and *music*.

The course in music at M. I. T. consists of three weekly lectures and five hours of preparation on the part of the student each week. It carries eight points of credit for each semester. The exact title of the course is "Introduction to Music" for the first semester and "Music Through the Ages" for the second semester. I will quote here the description of the two courses as it appears in the catalogue:

E 45. Introduction to Music. Designed to make students more familiar with the language of music and its universal literature including contemporary music. Rudiments of harmony and ear-training, and an outline of the terminology and history of music. Detailed analysis of masterpieces by various composers through lectures, demonstrations, and outside listenings. Reading assignments required. For students with little or no knowledge of music.

E 46. Music Through the Ages. Survey of the history of music with emphasis on musical examples from the Middle Ages, the Renaissance, the Baroque, and the Classic Era. Detailed analysis of the master works of Bach, Mozart, Beethoven. The Romantic Age and contemporary music, as well as a short historical analysis of opera. Lectures, demonstrations, outside listenings, and reading assignments.

Our textbook is "What to Listen for in Music" by Aaron Copland,† a concise description of the elements of music presented from the point of view of a prominent American composer. In addition we use an elementary music theory writing book which acquaints our students with the symbols of music, fundamental rhythm, melody and harmony as encountered in any better music analysis or commentary lecture.

By far the most part of the students' preparation is spent in listening *repeatedly* to a list of assigned phonograph records which are played for groups at stated hours or can be listened to individually through earphones. The list of

† Whittlesey House, McGraw-Hill Book Co., Inc., 1939.

music is selected so that there may be music of all times, allowing for examples of rhythmic, melodic, and harmonic application and building towards a rather inclusive picture of the world literature of music.

Obviously, the purpose of any music course of an introductory nature is to help students to become more discriminating and intelligent listeners. The customary procedure of reciting the lives and loves of composers is of little avail. The creation of art is influenced and motivated by deeper currents than the daily life experience of the composer. Tradition, currents of thought, vision, and the specific behavior of the material at hand all go into the making of worthwhile music. It helps little or nothing towards grasping some of the essentials of Bach's B minor Mass, for instance, to know that he had twenty children. Instead one rather studies the sources of the Lutheran chorale which lie in the Gregorian Chant and in popular Folksongs, the constructive and ecclesiastical evolution of Polyphony, the development of the Catholic Mass, Bach's attitude towards the pietists, and so on. Similarly, Beethoven's symphonies are not brought nearer to the listener by anecdotes dealing with his bad manners or his unhappy love life. Instead, an observation of the development of the classical symphony as a form, his rhythmic and harmonic innovations, and his being a musical messenger of the French Revolution, although perhaps less colorful in immediate appeal, lead more directly into the very heart of the musical matter. The set-up of a society at a given era in history, the status of the musical instruments available, the tonal and structural preoccupation of a group of musicians, the changing of the relations between church and state—all this goes into the making of worthwhile music.

While the first semester of the course is devoted to the fundamentals of musical grammar, to a detailed discussion of the elements of music, rhythm, melody, harmony, tone color, and its structural form, the remainder of the year brings a detailed analysis of musical masterpieces of the past and present. Mimeographed program notes, slides, diagrams of structure and illustrations at the piano are used continuously in class. Frequent performances of live music by professional musicians living in the Boston area supplement the musical food of the students which would lack "vitamins" if it were limited to "canned music" alone.

I am glad to say that our music course at M. I. T. is known as a stiff course. Although requiring no previous training or experience in music, yet it demands concentration and much active preparation and cooperation on the part of the student. There are quizzes—and students have flunked the course.

At present the course is taken by 233 seniors out of a class of 1057. It is held in two sections and requires the constant use of a considerable record library and a piano during lectures. This set-up requires considerable financing—it is helpful, though, to remember that physicists and chemists need laboratory equipment and are not accused of wasting their time during laboratory periods. Similarly, the occupation with music requires that time and money for equipment be spent in a "musical laboratory" and, although there may be little time and space for music in an instituiton, what little there is should be of the best. No matter how elementary the initial presentation, when dealing with Technology seniors, the instructor in music will find himself thrown into a discussion of complicated twelve tone theories or contradictions in the traditional musical concept of harmony whenever and wherever questions have been encouraged. There is no alibi for the music instructor in a Technological school by way of saying, "For this you need first two years of harmony and counterpoint." Nor is it acceptable to describe great music in merely aesthetic and fashionable terms. Nowadays, we hear men like President Conant of Harvard advocate that every Liberal Arts curriculum should include a course in the

History and in the Principles of Science; I would like to submit the proposal that the Engineering Curriculum should acquaint the technology students with the history and basic structure and content of music through the ages.

Conclusions

In conclusion, let me say that I do not really belong to the group of people who claim music as a cure-all for the world and its struggling citizens. No one will claim that the atom bomb is the solution for the evils of the world. However, we must try not to go too far in the opposite direction by asserting that music can be the solution for everything. It does not follow from the fact that in Berlin there are now five opera companies producing operas every day in the week as compared with two opera companies operating in New York City that the German people have made any progress toward a more democratic and peace-loving attitude. Yet I do believe that the total absence of music education and musical activity in our various secondary schools would amount to illiteracy in an important field for which there is no substitute.

Let me stress again that I have spoken of music at M. I. T. because I am not familiar with music in other technological schools. I am sure, however, that much is being done elsewhere and I am firmly convinced that whatever is being done in music depends upon the attitude and imagination of the administration, the various deans, and the department heads.

The Cam Motion Indicator—A New Teaching Aid

By JAY SCHEINMAN

Lecturer in Engineering Design, University of California

There has been a long-felt need in the field of Engineering Education for effective demonstration models to supplement lecture material presented to students in connection with various basic theoretical courses.

One fulfillment of this general need has been the recent development of a "Cam Motion Indicator," used with college classes in Engineering Kinematics to illustrate the motions of cam mechanisms. This machine, designed and constructed on the campus of the University of California at Berkeley, is capable of illustrating a variety of cam motions with different types of followers, and will automatically plot a displacement-time diagram by the mere manual turning of a crank!

The name of the device—"Cam Motion Indicator"—is of dual significance: there is indication of physical motion by the very movement of the component parts of the mechanism, and these movements are translated into mathematical terms through the plotting of the displacement-time curve which the machine automatically accomplishes.

As shown in Fig. 1, the Cam Indicator consists essentially of a supported wooden panel on which are mounted a steel cam, steel follower in brass guides, and movable plotting board. The cam, when manually rotated by means of its attached handle, will cause the follower to rise and fall in a vertical path. A ball-point pen, inserted in the body of the follower and held under spring tension, will then automatically describe a continuous displacement curve on the plotting board while the latter is being translated horizontally by the action of a train of gears mounted on the rear of the panel (see Fig. 2). The lead gear of this train is keyed to the cam shaft and the follower gear engages with a rack attached to the movable plotting board. Thus two basic forms of motion, rectilinear translation on the part of the cam follower, and angular rotation by the cam, are "harnessed" by the mechanism and are graphically delineated through the automatically-plotted cam diagram. The mechanism will further illustrate the effect of cam pressure angle on the body of the follower and its guide bearings.

Since the type of follower motion is controlled by the cam profile, innumerable forms of motion are made possible by differently shaped cams. The particular shape of cam surface employed in the Cam Indicator will produce four forms of follower motion based on fundamental mathematical laws, namely:

a. Harmonic Motion
b. Dwell
c. Combination Uniform Motion
d. Constantly accelerated and retarded motion

The relative characteristics of these specific motions may be observed by a study of the drawing attached to the model shown in Fig. 1, and are summarized in the following table:

Nature of Motion	Follower-Displacement (D) vs Cam Position (θ)	Type of Motion Curve	Velocity	Acceleration	Starting Force
Harmonic	$D \sim \sin\theta$ ($\sin t$)	Sine curve	Variable	Variable	Large
Uniform	$D \sim \theta(t)$	Straight line	Constant	θ (discontinuous at start and stop)	Very large
C.A.R.M.	$D \sim \theta^2$ (t^2)	Parabolic	Variable	Constant	Small
Dwell	No vertical displacement of follower as cam rotates				

Although the particular plate cam used with the indicator will produce only the aforementioned follower motions, the follower itself provides a greater flexibility of performance, as it has been ground to a point at one end and contains a roller bearing at the other. By simply inverting the follower in its guides the relative advantages of sliding versus rolling contact may be quickly and effectively demonstrated. In addition, the construction of the panel board permits a change of position of the follower and its guide with respect to the cam axis, converting the system from an offset-follower-cam arrangement to one of alignment. This latter change is quite easily accomplished by simply lifting the follower and its guides out of the panel grooves provided for the offset position, and placing these parts into parallel "alignment grooves." Figs. 1 and 2 illustrate the construction quite clearly

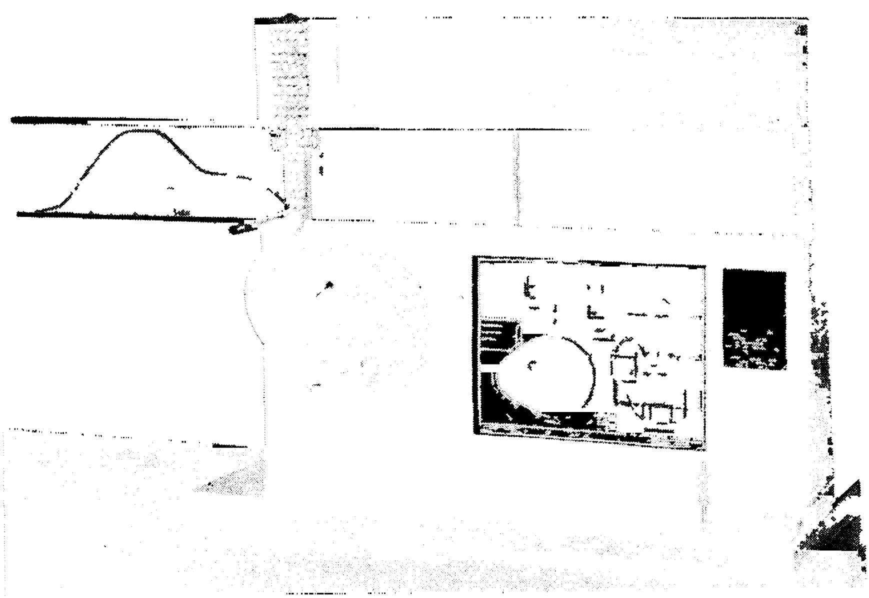


FIG. 1.

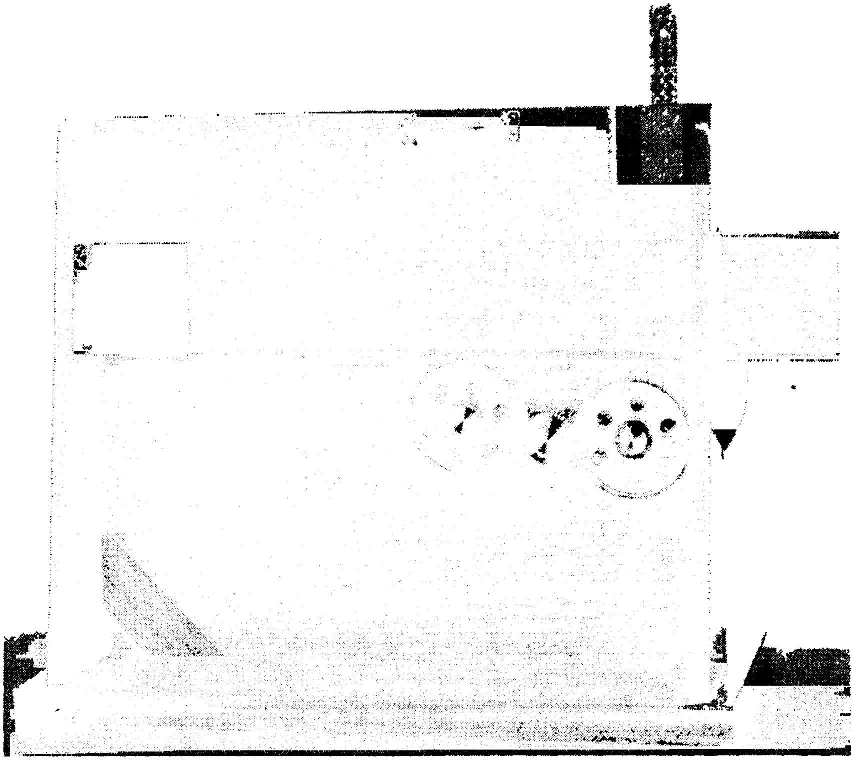


FIG. 2.

Sufficient versatility has been incorporated in the construction of the Cam Motion Indicator to permit replacement of the plate cam by cams of alternate shape, thereby enabling this mechanism to plot an infinite variety of displacement curves by such simple substitution, using either the pointed or roller follower in its aligned or offset position. In this manner a fairly wide assortment of performances may be achieved by the model.

It will be observed that space has been provided on the face of the panel board for the mounting of a drawing which illustrates the geometry of the plate cam design, and shows the plotted velocity and acceleration motion curves which are, of course, the first and second derivatives, respectively, of the displacement curve. (As a laboratory exercise, these derived curves may be readily plotted by the student through application of the principles of the Graphical Calculus.) The drawing further shows the relative values of pressure angles determined at various points along the cam's lateral surface; the specified direction of cam rotation; and it also records nomenclature and terminology pertinent to cam theory and design.

One design problem on which the plate cam of the Indicator has been based is also attached to the panel board in statement form. For the convenience of the reader, this problem is quoted herewith:

"A plate cam revolves in a counterclockwise direction at the rate of 5 R.P.M., transmitting the following motion to a pointed follower whose path is a vertical line: (The cam axis is offset

2″ below and 1.3″ to the right of the initial position of a point on the follower).

"Follower rises 4″ with harmonic motion during first four seconds; dwells for 1 second; then drops 2″ in 2 seconds with straight-line combination motion *; then dwells for one second; and finally descends for the last 4 seconds with C.A.R.M. motion to the starting point."

The Cam Motion Indicator possesses considerable course adaptability. As mentioned in the opening paragraphs of this paper, the model serves primarily to supplement a theoretical discussion of the principles of cam design and application through its use as a demonstration model—available laboratory equipment to enhance the study of technical mechanics being woefully inadequate in many engineering colleges. It further provides the student with a tangible means of enabling him to crystallize his concepts of cam mechanisms as he proceeds with the layout of such problems in the laboratory. It is the author's belief that courses in Engineering Mechanics, Machine Design, Mechanics of Machinery, and the like, could therefore be made more interesting, be given a more practical trend, and otherwise enlivened by the use of such demonstration equipment.

In conclusion, it would seem that a few words might be helpful to those planning to build similar devices for their own use. The model described is of sufficiently simple design to involve relatively low cost and ease of construction. Yet it must be borne in mind that the mechanism is intended to be used as a demonstration model exclusively. Extreme accuracy of performance is not only difficult to obtain within the feasible limits of material, time, money and effort, but is actually unwarranted if the machine is to serve its intended purpose. As a teaching aid, however, it is firmly believed that the Cam Motion Indicator will prove to be, in its own specialized way, a valuable adjunct to a more significant engineering education.

* Straight-line combination motion is modified uniform motion to avoid abrupt starting and stopping of the follower.

The Dilemma of the Young Engineering Teacher

By CARL M. COOPER and J. W. DONNELL

Michigan State College

The young man who intends to become a teacher of engineering today is faced with the problem of planning his preparation for such a career. One of his first problems is to decide how much formal education to acquire and whether or not to obtain actual engineering experience in industry. Obviously his first step is to obtain a bachelor's degree in engineering as this is basic either for a job of engineering in industry or for further progress in academic fields. The first question then is what to do after securing the first degree—whether to get out and get a job and thus put to the acid test of actual plant operation all this knowledge he has acquired or whether to continue in school working toward higher degrees, and picking up a little teaching as he goes along.

The Academic Route

There are advantages to the prospective young teacher in taking the academic route, that is in beginning immediately to study for the Ph.D. degree after having obtained his bachelor's degree, without having had any actual engineering experience in industry. One of the advantages is the relative cheapness of this route. Only three nine-month periods are usually required for the Ph.D. degree beyond that required for the bachelor's degree. Moreover in most cases the student's expenses can be reduced by summer work, and the plan partly financed by work of a teaching nature along with the graduate work. However, it is true that should too heavy a teaching load be attempted while doing graduate work the time required for the degree will be extended. Contributing also to the economy of this route is the fact that the student's standard of living is considerably lower than living standards in industry so that if he continues in school without interruption, his financial outlay will be considerably less than it would be if he entered industry and then returned to school. Another advantage, which is of no small consequence, is the ability of the young man who continues in school to understand readily what is desired of him in his classes. If he has continued the business of going to school from the primary grades on to his Ph.D. degree without a serious interruption, he realizes what is required of him by his teachers. This advantage shows itself particularly well if we compare two students working for the Ph.D degree, one of whom has never had a break between the bachelor's degree and the graduate work while the other has come in from industry. The latter finds it rather difficult to know exactly what is expected of him. In other words, he has lost the knack of the teacher-student relationship which he knew well during his undergraduate days and this is a serious handicap.

Moreover, if one follows the academic route, he will not be subjected to the radical changes in his way of life involved in moving from school work to industry and back for he will, in a way, be following the same kind of work he began as a child. The radical change from school work to industry has been a decided stumbling block in the career of many a man. Finally there is the recognition which the possession of the Ph.D.

degree gives among college associates and college administrators. Nowadays a Ph.D. degree can be looked upon pretty much as the teacher's union card without which, among most college administrators, it is virtually impossible to hold down a responsible position. One can easily see the reason for this attitude on the part of college administrators in the lack of other means of gauging a teacher's ability. Teaching ability and teaching effectiveness are hard to evaluate and degrees are tangible.

Along with the advantages of the academic route there are some disadvantages to the young teacher. It has been stated that no one can speak with any authority on engineering subjects unless he has obtained some industrial engineering experience. This is perhaps too strong a statement. Nevertheless, it does have some element of truth in it. Perhaps a better way of stating it is to say that the teacher with no engineering experience has no way of knowing what particular fundamentals to stress in his teaching. For example, the young teacher may go into rather elaborate calculations regarding a heat exchanger without any mention of the fouling factor which the design engineer in industry must put on in a design calculation if he is to have a satisfactory design while in most cases this fouling factor offers more resistance to flow of heat than all other factors combined.

The effect of this lack of first-hand knowledge was evident recently in a conversation with a colleague. A large boiler had recently been installed in the local community power house and in describing the size of the boiler a newspaper account stated that it was 120 ft. tall and had a drum 60 ft. in diameter. Our colleague remarked, upon being told of this description, that he did not know whether this was out of line or not, even though the pressure on the boiler was, as he knew, some 900 pounds per square inch. The young teacher without industrial experience cannot know what particular fundamentals to emphasize more than others. His only guides are his teachers or his books, and books are sometimes written by people no more experienced than he. Yet one must remember that he is called upon to prepare a product for industry, since at least 80% of his product goes into industry. We are not suggesting a trade school but are not engineering fundamentals necessary if we are to continue as Engineering Schools? Another serious disadvantage offered by the academic route is the grave psychological effect on the teacher of dealing continuously with immature minds, of never having to deal with his equals. Students know that they must please their teachers, or low grades may result; and this is bad for the teachers ego. One of the fundamentals upon which business in this country is based is competition and, we all recognize that competition makes better products; yet this is the very thing that the school teacher who follows the academic route exclusively never experiences.

Lack of first-hand knowledge of the needs of industry affects the young teacher's work in another way. Not having pertinent problems of his own for his students he is likely to resort to a series of small problems of little value, but which offer something for the student to exercise his mental powers upon. In this way the course sometimes degenerates into an exercise in mental gymnastics.

The Industrial Route

It is clear that the advantages to the young teacher of following the academic route far outweigh the disadvantages. Now what happens if he chooses to enter industry after receiving his bachelor's degree? The first and most obvious gain for him is that of getting first-hand knowledge. A second advantage which comes to the young man who elects industry is the gain in tolerance, cooperation, and humility, by-products of his job and traits much needed by the teacher. In industry one works closely with his equals and his superiors as well as with

his inferiors. If he cannot or will not cooperate, he does not last long in industry. His mistakes and failures, unlike those in teaching, are visible and tangible, and through them he learns humility and tolerance for the mistakes and failures of others.

One of the very first things that the young engineer learns on getting out into industry is that he must sell himself to his superiors. His employers do not take it for granted that, because he has the scholastic training required for his job he can do the job. This he has to prove. Some of the most successful engineers that we know spend as much as half their time selling their wares to their superiors. A teacher who has had this industrial experience can use it to advantage in his teaching. We all recognize the lack of this ability among students, and we have made some attempts to correct it by having them write decent reports and make decent practice speeches. Here the experienced engineer has a decided advantage over the inexperienced one because any engineering student will resist good report writing as well as good speech making unless he is given a good sound reason why it is necessary in his profession.

The experience route then, offers some advantage to our young teacher, but it has disadvantages too. The engineer from industry who turns teacher may find himself in trouble at once. He may know his subject but it is another thing to get it across to the students. In industry he has been dealing with mature minds, and he overestimates the student's ability and overloads him by giving him problems which are too long or which require judgment which the student lacks through immaturity or inexperience. Problems that are filled with practical assumptions if not carefully watched tend to confuse the student, accustomed as he is to neat problems with definite answers. Another disadvantage of the experience route is that if the young engineer knows that he is ultimately going to become a teacher, he may never pay much attention to his work in industry, but touch only on the outer fringes of the profession because he does not intend to make a career of it. Therefore, he may never truly see engineering work. There is, of course, another type of engineer one who has made a success in industry and then turns to teaching not having previously planned to teach. Sometimes such a teacher intends to retire to teaching, but teaching is not a profession to which one can retire. Young, immature minds expect enthusiasm and action and will not tolerate the type of person who is "retiring" to teaching. Another serious disadvantage of the experience route lies in the possible loss of technical ability. It has been stated that nine out of every ten engineers who go into industry have within ten years passed from technical work into executive work. As an executive it is difficult to find time to keep up with the new technical advances and thus if the young engineer intends to teach he shouldn't remain too long in industry. Still another type of engineer plans to go into teaching after leaving industry but is unwilling to live on a teacher's salary and expects to augment his pay by consulting. Certainly if he is going to live on the scale to which he is accustomed, if he has been a success in industry, he must augment his teaching salary. But therein lies a very great danger. Teaching is a full-time job and teaching can very easily be neglected if one takes on too much consulting.

Combination of Academic and Industrial Routes

A proper combination of academic achievement and industrial experience would seem to be the ideal course for the young teacher of engineering, but such a combination is expensive and time consuming and would mean adjustment and readjustment for the young teacher.

Just when and how the young man, who elects industry after his bachelor's degree and later returns to teach, is to se-

cure his advanced degrees is a problem. If he takes time off to secure them, he must find money for some three years without income. If he teaches as he studies, it will take longer than three years, and his scale of living will necessarily be lower than when he was industry. If he was successful in industry and can return to it, he will be sorely tempted to do so.

On the other hand, will the young man who continued in school through his Ph.D. degree then leave the school room for industrial training? More and more the answer is, "no." He is used to the academic pace and generally dislikes the faster pace of industry and resents its discipline and its lack of deference to his scholarly attainments. We live in a time in which security is valued above all else. The days when a young man sought the difficult or the adventurous path to prove his mettle have gone. Accordingly when the young would-be teacher has won his doctor's degree, he will not, as a rule, willingly venture forth from the security of the academic elms where the mere possession of his degrees is sometimes accepted as evidence that he is and will be adequate to any demands made upon him.

Since some 80% of our young engineers go into industry, is it not fair to assume that industry should have something to say about how their young engineers should be trained? Some companies not only make this assumption but also state that college professors do not know what is required in industry. As a result at least one company, namely the Monsanto Chemical Company, has agreed to take a certain number of young professors into their plant for a year each to acquaint them more thoroughly with what they demand of engineering graduates, with the understanding, of course, that they will return to their colleges and impart this knowledge to their students.

Before leaving the question of a combination of the two routes, it might be well to look into the European educational system which also is practiced in South America. In this system industry works very closely with colleges and universities supplying them with some of their executives who do part-time teaching and part-time industrial work and in most cases a heavy exchange of professional engineers is carried out. This system would appear to be an ideal system and there has been a tendency in this country to turn to these methods as indicated by the Monsanto Chemical Company's plan as well as plans of some others like Westinghouse and General Electric. However, it is unlikely that this type of training will soon become sufficiently prevalent for the young teacher to depend upon.

The cooperative colleges have solved the problem in their own way, and there is talk that some engineering schools plan to make at least a year of industrial experience a prerequisite for admittance to candidacy for the doctor's degree.

Enlarged research programs which would include all our teachers would help if the money could be found for the projects, and teaching schedules adjusted to permit participation by all our faculty members.

At any rate the dilemma seems, after all, to be that of the engineering schools.

Who Is Responsible for the Placement of the Graduate?*

By W. C. van DYCK

Supervisor of College Graduate Training, Caterpillar Tractor Co., Peoria, Illinois

Introduction

The placement of the engineering graduate from the standpoint of the student, the college staff, and industry presents a complex series of related problems. The general purpose of this discussion will be to describe these problems with suggestions for solutions.

There has been a marked shift in the responsibility for the placement of students at most larger colleges and universities during the last ten or fifteen years. Industrial Personnel men often wrote individually to the Head of each college department if they wished to interview Mechanical, Electrical and Civil Engineers on the same campus. This arrangement was awkward and time consuming. In the interests of efficiency a change was inevitable. So, in most cases, the position of Placement Director was instituted. This coordinator is now responsible for arranging interview schedules for all college departments with industrial representatives. This centering of responsibility in one office and one person has enabled the interviewer to talk with a greater number of students of varied educational backgrounds, in a shorter length of time, and with fewer preliminary arrangements.

This shifting of responsibility has improved efficiency, but in most cases it has resulted in a corresponding lessening in the personal contacts between industrial and business representatives and members of college staffs. At universities where there is a placement director, the industrial representative seldom meets individual Department Heads unless he asks to. That close personal relationship between the man who teaches the students and the man who hires the graduate may be losing ground.

I often wonder if many professors and Department Heads don't feel that a burden has been lifted from their shoulders when a placement director takes charge. Yet, most placement directors agree they do not have a close enough contact with each individual student to counsel him on placement matters. The purpose of this discussion is to suggest who should carry a large portion of the responsibility for the placement of the graduate regardless of the organizational arrangement.

It may appear that the writer, being in industry, is a little presumptuous in suggesting to you what your responsibilities as college men may be. However, in the writer's contacts with students at campus interviews and in supervising young graduates in industry, certain basic fundamentals kept coming back again and again. These thoughts are presented here for you to evaluate as you will. They are proposed as ideas for your consideration. The hypothesis taken is that the most important part in the proper placement procedure comes before the job interview and perhaps before the senior year.

Who is Responsible?

Almost every interviewer asks the student during employment discussions,

* Presented at the Missouri Section of A.S.E.E. in St. Louis, April 9, 1949.

"What type of work do you feel you would like to do?" The student's answer may well be one of the most important statements in his engineering career. Yet, on what does he base his decision? In the experience of the writer, slightly over one-half of the students have reached this decision because of a strong liking for some particular course or professor. If the applicant enjoyed his Motion and Time Study Course, he may ask for production work. If he disliked machine design, he may say, "Anywhere but on a board." The teacher of *any* engineering course, whether he realizes it or not, is influencing men in the choice of their careers. Naturally, there are other influences on the student resulting from actual experiences or from consultations with friends and relatives in Engineering work.

During the past few years, many companies have had difficulty in hiring well-qualified men for design. Too many students say, "I don't want to be stuck on a board." If the student is queried further, the interviewer finds that he often was unenthusiastic about his design courses, and feels that design work in industry may be equally distasteful. In many cases the student may not be basically qualified for this type of work. However, we have hired graduates in our one-year training course with expressed interest in other departments. During their short period of training in the Engineering Department in the orientation course, they discover that design is more creative and interesting than they had imagined. Some of these men have altered their original goal and have made engineering design their career. Many more students today could find a lifetime of happiness and service in design, but are steered away from it by incorrect impressions obtained in college courses. This is not necessarily a criticism of machine design courses or professors. It is realized that certain principles must be taught in a limited number of hours. In most cases there is neither time nor staff to allow each student to carry out a separate project. It would also be impossible to duplicate conditions in industry, but an alert and well-informed teacher can help his students understand the relation of what they are doing as students to what a designer may do in industry. Thus a more nearly correct picture of design may be presented to the student. Naturally, this picture will not always be favorable as many men are not well suited to this endeavor.

This same misunderstanding occurs in other fields as well as design. Nearly every young engineering student likes to be around machinery. His laboratory courses give him this opportunity, and he may build up in his mind a strong liking for a field he calls "testing." Perhaps his greatest contribution could be in production, but seldom gets into this branch of industry because he seldom asks for it. Industry may have a poor "tester" or development engineer and have lost a capable production man. Again, an incorrect impression gained in a college course has led to unsatisfactory placement.

After a day's interviewing on a campus, it is readily apparent to the interviewer who the influential professors are. Student after student comes in to the interview with a burning desire for the same type of work. I usually seek out these professors to know them better. Without exception, they are men with a broad understanding of the end point of a student's training—the work he will do in industry.

Thus, some responsibility for the proper placement of the graduate must fall on each professor or instructor who influences the thinking of the undergraduate. True, this influence is unwitting and involuntary, but nevertheless it does exist and plays an important role in determining the future of the graduate.

Department Heads and Placement Directors guide general placement policies. They usually maintain the contacts with representatives of industry during their interviewing visits to the campus. How-

ever, the instructors and professors who may have the greatest basic influence on the student in placement matters could very well be better prepared to give guidance on placement as the student progresses through his four years of engineering.

Vehicles to Better Understanding

The professors or instructors of routine undergraduate courses have usually had some practical or industrial experience in the field they are teaching. The following are several ideas for strengthening this knowledge and understanding of modern industry. As implied earlier, the primary reason for these proposals is to lead to better placement of the graduate. I think you will agree that they will make for more effective teaching as well.

Several companies have provisions for giving summer employment to engineering students. Other companies are considering the inauguration of such programs. Among other things, this training is intended to allow the student to become familiar with industry and opportunities that might await him in different departments. A few companies try to accomplish this goal by giving the student training in several different divisions of the office and factory. Too often the student does one routine job for the entire three months. He understands quite thoroughly the jobs that run over his particular radial drill. However, is he any better qualified to judge his fitness for product reasearch? Or for Sales?

On the other hand, suppose this Company employed, during the summer months, a college instructor or assistant professor. The professor is qualified to handle responsible engineering work. He is more mature and has a broader outlook than a student. If he were given work of a technical nature in the field of his specialty, he could likely make a real contribution to the Company's engineering program even during his short stay. To refer to an earlier illustration, a machine design professor might well work in industry during the summer on some design problem that has been laid aside because it is not pressing. When he returns to his classes in the fall he would likely weave into his teaching the techniques and methods used by industry, making his course more practical and interesting. Students could come to him to receive guidance in this field. Thus, one professor might influence many students. The Company has accomplished its goal more completely than it possibly could by the employment of one student.

This is not intended to discourage the employment of college students by industry during vacation periods. It is intended to illustrate the greater benefit obtained by the employment of instructors if the goal is to help the students in placement matters. This suggestion is not original, but its intended results may be. When our Company was considering the employment of professors during the summer vacation period or for sabbatical leaves, a warning was given us by the Head of Mechanical Engineering at a large midwestern university. Rather than have us select the man from those desiring this type of work, and then place him on any assignment, he suggested we present to the College Department Head the kinds of technical assignments available so that he could choose the man from his staff best suited to fill them. This would insure the greatest satisfaction on the part of both parties.

It has been our custom to spend two or three days on each college campus when we interview engineering seniors. On one particular campus, our representative usually eats lunch with one of the Department Heads. However, each day there is also present at the lunch table one of the instructors or assistant professors from that Department. Often, he is a rather young man, new to the profession. This young professor enters into the discussion at the table whether

on the latest type of industrial development or on the type of salad dressing. But he gets the chance to meet representatives from industry and to swap ideas. He discovers what openings exist and the types of men desired to fill these vacancies. In other words, he gets the opportunity to observe the end point of his work—the placement of the graduate. Now it is clearly impractical to have each instructor at lunch every day. However, there are usually enough visitors from industry so that nearly every week during the spring, the young professor might spend some time with industrial people.

It is about the time of year for annual senior inspection trips. College and industrial men alike are well acquainted with these tours of industrial and business establishments. In most cases there are from thirty to a hundred students who spend a few hours going up and down the aisles of production lines viewing operations first-hand. It is a very worthwhile idea and should be continued and expanded.

Professorial Visitations

But, too often, the students gain merely a general impression. If professors are to influence students on placement matters they should be even better informed. Realizing this, about two years ago we invited to visit us a group of professors of theoretical and applied mechanics from one of the nearby universities from whom we hire many men. We planned a little different type of inspection trip than was ordinarily arranged for students. The professors drove over in cars early to spend the entire day in our Research Department. Our Staff Engineers acted as escorts during the general tour of Research activities in the morning. The size of each group was limited to four. Occasionally, as much as twenty minutes was spent in one spot answering the questions of our guests, and giving more details than were readily apparent from a visual inspection of the machinery. Luncheon was a leisurely affair. Between each Company man was a professor in order to stimulate acquaintance between the two groups. In the afternoon our guests and our engineers divided into small discussion groups of from five to seven men to discuss technical problems in fields of mutual interests. Fancy speeches were out. Just before dinner, members of our staff discussed the progress of men who had recently graduated from the college. Now these professors who visited us were representative of an entire college department from the newest instructor to the Department Head. They gained an entirely different picture of the Company than would a group of students watching parts being machined and assembled. They got to know our men and to understand their problems and goals. Needless to say, this experiment has been repeated with a group from another college. It is a slow process, but a thorough one. What's more, its influence is lasting.

Perhaps this type of program is a little too ambitious to work with all industries. However, it would seem to be part of the job of each professor to be generally informed on the companies where numbers of his graduates are placed. This job is easy to push to the background when days are so fully occupied with duties on the campus; but it would seem important enough to be placed, occasionally, ahead of routine business. Incidentally, the spark in such a contact between industry and the college may have to be generated by the college.

We often have small groups of students visit our plant on their own initiative to become acquainted with the factory. I cannot remember any group of professors who came to us under like circumstances. However, they would certainly be welcomed and given the time of top flight engineering people.

Incidentally, in all of the above sug-

gested means of contacts between college men and industry, the road is a two-lane highway. Each group influences the other. Industrial people may find real help in the solution of technical problems. They may become more aware of the value of an engineering education and make places for more graduates.

It might be well to stop here for a moment to add a word of caution. As you know, a little knowledge can be a dangerous thing. Teachers in college may form an opinion of industry from merely one contact. As an illustration, one professor of mechanical drawing had worked several months in the Engineering Department of a medium sized industry. He had been under poor supervision, which was later changed. However, he was prejudiced by this experience towards all industry and especially Engineering Department work. His attitude was reflected in his students when they discussed employment with industrial interviewers.

Student's Viewpoints

It is our policy to question each student during the interview as to what he means by Sales or Testing or Design. These departments are organized differently in different companies. In one, Sales may consist of direct selling to customers, where in another, Sales may consist of acting as a technical consultant to salesmen. The requirements and responsibilities of the jobs are much different, yet in both cases the brief job description is Sales. Because of this divergence in organization between companies, the wider the professor's contacts with different industries both large and small, the better job of guidance he may do.

This condition is a little like the opinion that an industrial man may get from a single contact with a college. This spring a manager from another Department went with our regular representative to aid in the interviews of students. At the first college visited, there were few men interested in the type of work he supervised. In general, they were not too well informed. He felt that his time could have been spent better by remaining at the factory. However, after three and four visits to different colleges, his attitude changed. He began to appreciate the problems of the colleges, and by the law of averages talked with more seniors interested in his specialty. Now his opinions are the best, but if his contacts had ceased after his first visit, he would likely have been quite intolerant of our engineering education and placement systems.

So don't let one contact with industry or business on the part of a staff member of a college be sufficient to inform him. No two industries are alike and methods are continually changing. An up-to-date clear understanding should replace old prejudices if they exist.

Placement is not something to be thought about only during the last semester of the senior year. The end point of their college work must be kept alive in the minds of students at all times. This will allow more direction to their efforts during their formal scholastic training. Professors of undergraduate courses require an up-to-date understanding of industry if they wish to exert the right influence during these idea forming years.

Other Influences on Students

The influence of the teacher on a student's occupational interests has been brought out. The effect this may have on the student's placement has been discussed. However, there is another field in which each instructor exerts a strong influence which may well have even a greater bearing on the student's placement and his future success and happiness. This is the field of correct dealing with people, and the ability to get along well with others. Because, as you know, the instructor is not merely a purveyor of technical information. He cannot

help but teach by example whether good relations or bad. Take, for example, the professor who is habitually careless or even sloppy in his appearance. To the student he is still a successful engineer. So the student may come to the interview with no tie and a day's growth of beard. This has happened. The results are obvious. Or take the case of a professor of mechanical engineering who was intolerant towards economics courses. His attitude was reflected in his students by their feeling of a disdain for any subject not strictly technical. This, incidentally, reduced their grade point average in economics, but more seriously encouraged them to neglect to round out their educations. The professor who uses profanity encourages his students to do likewise. And some students feel the interviewer won't think them a regular guy unless they say "hell" and "damn" or something else even more "manly." A professor who bawls out a slow student before the entire class does harm not only to that student, but at the same time gives an object lesson in poor human relations to the rest of the group. The veterans now in school are older and are perhaps influenced less by these actions than are the younger students. However, the younger students will soon predominate.

Conclusion

Who is responsible for placement? Many people—yes—but perhaps most of all the men under whom our students study. During these days of enlarged staffs which were rapidly expanded upon conclusion of the war, more attention might be given to the understanding of the end point of formal education by these teachers. This paper has proposed three definite means, all of which have been operated successfully under certain conditions. These are not simple solutions. Problems involving people seldom have simple answers. However, it is hoped these proposals will also bring about a closer bond of friendship and understanding between individuals in education and in industry and business which cannot help but strengthen both.

So no matter what happens to be the placement arrangement at an engineering college, it is the professors who have the greatest influence on the student. Through their teaching of technical subjects, the students gain an insight into engineering work as a career. These teachers have done an unusually fine job in the past. With a closer bond between them and industry they will be in a position to be even more effective. This will promote a happier and more successful career for the graduate.

Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Friday, September 1, 1950, at Northwestern University, Evanston, Illinois. Those present were: F. M. Dawson, *President,* H. H. Armsby, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, A. B. Bronwell, and M. Wiltberger.

Report of the Secretary

The Secretary reported that substantially all of the Committees have been appointed. F. L. Wilkinson, Jr. was approved as Chairman of the Costs of Engineering Education Committee. Thorndike Saville was appointed as representative to ECPD for a three year term.

Report of the Treasurer

The report of the Treasurer was presented and accepted. At the suggestion of the Secretary, the Board approved an increase in the Secretary's bond from $5,000 to $35,000.

A request of ECPD for an increased appropriation of $500 for the coming year was deferred, pending further information and clarification of the probable future financial position of the ASEE.

Report of the Vice Presidents

Mr. Armsby stated that the University of Tennessee had submitted a constitution for a Branch of the ASEE. A motion to approve authorization of the Branch was passed. The approval of a constitution of the University of Maine was referred to the Committee on Sections and Branches.

Mr. Armsby reported that the names of several ASEE members have been submitted to the State Department and referred to the White House as nominees for the Advisory Board which is to assist the State Department in the basic policies relating to the Point Four Program. He stated that, in addition to the Advisory Board, a number of Committees representing specialized areas will be appointed. It may be possible to have Society members appointed either to the Advisory Board or to one or more of the working Committees.

Dr. Grinter presented the requests for ASEE sponsorship of Summer Schools which were submitted by the Engineering Drawing Division, Humanistic-Social Division, and the Mechanical Engineering Division. The Board voted to approve ASEE sponsorship of these three Summer Schools.

Dr. Grinter discussed the progress of the Committee on Improvement of Teaching. He stated that the work of the Committee will be subdivided into three categories, with subcommittees arranged geographically so as to minimize travel. He also stated that the Committee will attempt to get each dean of engineering to establish a local subcommittee within his own institution. Activities of the institutional subcommittees will be reported back to the central Committee in order to provide a pool of case studies.

Dean Terman, reporting for the ECAC, presented the views of the Executive Committee of the ECAC on the proposal of the Committee on International Relations to set up ASEE sponsored fellowships in engineering colleges. According to the proposed plan, participating institutions would each designate one or more scholarships or fellowships to be granted to foreign students and would assist the student in obtaining living expenses. Dean Terman stated that the Executive Committee of the ECAC accepted the plan, although there appeared to be mild skepticism on the part of the Committee

members as to whether or not the plan would be widely adopted.

Dr. Rosselot reported that the ECRC is planning to publish a Directory of Research. This project may be in cooperation with the Research and Development Board of the U. S. Military Establishment.

Constitutional Amendment Providing for Affiliate Branches in Technical Institutes

Vice President Armsby submitted a proposed amendment to the Constitution which would provide for authorization of Affiliate Branches in Technical Institutes. It would also provide for clarification of other matters relating to the authorization of Sections and Branches. The amendments were referred to the Committee on Constitution and By-Laws.

Emergency Educational Programs

The Secretary reported on a conference which he had with Dean Saville regarding the planning of emergency educational programs. Experience during the last war has indicated the necessity of adequate liaison between the Society and representatives in the Military Establishment as well as other interested government agencies responsible for planning educational programs. Dean Saville suggested that a meeting of his Coordinating Committee, together with representatives of the Military Establishment and other interested governmental agencies, be held in Washington, D. C. at the time of the ECRC and ECAC meetings. This meeting would consist of a frank and open discussion of the whole problem of emergency educational programs. Appropriate follow up action could then be taken by various committees of the Society.

Plans For Meetings In Washington, D. C. November 16–17, 1950

The ECAC and ECRC plan to have joint meetings in Washington, D. C. immediately after the Land Grant Association meetings.

These meetings will center around the following topics: 1) general problem of proper utilization of technical manpower; 2) manpower controls; 3) problem of training; 4) utilization of research facilities in universities. The meetings will be open to members of the Society unless a closed meeting appears desirable.

There will be a breakfast meeting of the General Council at 7:45 until 9:45 A.M. on Thursday, November 16.

Cooperation With American Council On Education

A plan has been worked out with the ACE whereby bulletins of the ACE will be sent to the Society for distribution to deans of engineering colleges. The Society will pay the cost of these bulletins.

The Executive Board voted to suggest to ACE that an engineering college president or dean be added to their Committee on Relationships of Higher Education to the Federal Government.

National Science Foundation

President Dawson stated that he had received word that the Appropriations Committee of the House of Representatives has removed the $500,000 appropriation for organization of the National Science Foundation from the Appropriations Bill. He reported that he had sent a telegram to Senator O'Mahoney urging that funds be appropriated for the Science Foundation and stating that this is more important than expenditure of the same amount of money in other phases of the preparedness program.

Vocational Training In U. S. Department of Labor

President Dawson stated that there was a possibility that the National Securities Resources Board would recommend placing the responsibility for vocational training programs in the U. S. Department of Labor. Since the Department of Labor has had very little previous experience with training programs of this nature and the U. S. Office of Education has had very extensive experience, it was felt that

such a move would be extremely unfortunate. Accordingly he sent a telegram to the National Securities Resources Board strongly urging that training programs dealing with the emergency be vested in the U. S. Office of Education rather than in the Department of Labor or other governmental agencies.

Draft Deferment

The Secretary reported that an Advisory Committee under the Chairmanship of Dr. Trytten has submitted to General Hershey a revision in the plan for draft deferment of students. It is expected that action will be taken on this proposal in the near future. Also, President Truman has requested that a provision be inserted in the Universal Military Training bill whereby students who have been accepted by a college or university will be required to take only six months of military training.

E.S.M.W.T. Proposals

Vice President Armsby reported on tentative legislation which is being drawn up by the Office of Education for reactivation of educational programs similar to the E.S.M.W.T. programs.

ECAC Survey of Employment of 1950 Graduates

The Manpower Committee of the EC AC had previously proposed to conduct a survey to analyze the types of jobs accepted by engineering students who graduated in 1950. Because of the military preparedness program, it appeared that this survey would have very little predictive value for future years. The Manpower Committee has proposed studying this matter further with a view toward making a somewhat similar survey to assist in any future mobilization of technical manpower.

Teaching Aids Committee

A suggestion has been made that the Teaching Aids Committee be appointed as a full Committee of the Society rather than as a subcommittee of the Division of Educational Methods. This Committee will solicit funds from industry in order to carry out its evaluation program. In view of the financial responsibility of this group and also in order to focus the attention of the entire Society upon the activities of this Committee, it was proposed that this Committee be made a Committee of the Society and report directly to either the Council or the Executive Board. This was referred to Vice President Grinter for study.

Engineering Centennial of 1952

A motion was made and passed that the ASEE will accept the invitation of the American Society of Civil Engineers to take part in its Centennial in Chicago in 1952.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Committees, 1950-51

EXECUTIVE BOARD: F. M. Dawson, *Chairman,* State University of Iowa, Iowa City, Ia., H. H. Armsby, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, A. B. Bronwell.

PROGRAM: Members of the Executive Board.

PUBLICATION: A. B. Bronwell, *Chairman,* Northwestern University, Evanston, Ill., F. M. Dawson, T. Saville, C. L. Skelley, J. S. Thompson.

CONSTITUTION AND BY-LAWS: W. C. White, *Chairman,* Northeastern University, Boston, Mass., H. O. Croft, L. A. Bingham, P. Cloke, K. L. Holderman, J. B. McGivern, M. C. Giannini.

ATOMIC ENERGY CONFERENCES: (Steering Committee): H. H. Armsby, *Chairman,* U. S. Office of Education, Washington, D. C., H. E. Wessman, M. P. O'Brien, O. W. Eshbach, R. C. Ernst, H. B. Hanstein, P. N. Powers, *Subcommittees:* G. W. Gleeson, A. S. Janssen, E. W. Schilling, R. D. Sloan, H. E. Wessman, *Chairman;* E. B. Norris, E. E. Litkenhous, W. J. Seeley, N. W. Dougherty, N. G. Pollard, H. M. Roth, R. C. Ernst, *Chairman;*

COSTS OF ENGINEERING EDUCATION: F. L. Wilkinson, *Chairman,* Rose Polytechnic Institute, Terre Haute, Indiana, H. P. Hammond, W. L. Everitt, M. P. O'Brien, H. S. Rogers, W. R. Woolrich, T. Saville, A. B. Bronwell.

ENGINEERING ECONOMY: W. D. McIlvaine, *Chairman,* University of Alabama, University, Ala.

ENGINEERING SCHOOL LIBRARIES: E. A. Chapman, *Chairman,* Rensselaer Polytechnic Institute, Troy, N. Y., J. E. Allerding, P. Leslie, J. B. O'Farrell, W. R. Harvey, D. A. Webb.

GEORGE WESTINGHOUSE AWARD: R. E. Vivian, *Chairman,* University of Southern California, Los Angeles, Calif.; for four years, H. P. Hammond, F. B. Seely; for three years, N. A. Christensen, R. E. Vivian; for two years, V. L. Doughtie, W. L. Everitt; for one year, E. B. Norris, H. E. Wessman; H. N. Muller. *Ex-Officio.*

IMPROVEMENT OF TEACHING: (Steering Committee): L. E. Grinter, *Chairman,* Illinois Institute of Technology, Chicago, Ill., H. H. Armsby, A. B. Bronwell, J. F. Calvert, J. W. Cell, N. A. Christensen, A. P. Colburn, R. E. Doherty, E. E. Dreese, C. G. Duncombe, R. Eliassen, W. L. Everitt, R. E. Fadum, V. M. Faires, H. P. Hammond, E. Hutchisson, F. C. Lindvall, L. C. Maugh, K. B. McEachron, Jr., B. V. Moore, S. P. Olmsted, J. T. Rettaliata, H. S. Rogers, T. Saville, J. F. D. Smith, H. L. Solberg, B. R. Teare, E. A. Walker, E. Weber, J. G. Woodburn, F. H. Pumphrey.

INDUSTRIAL HYGIENE, SAFETY AND FIRE PREVENTION: D. E. Henderson, *Chairman,* North Carolina State College, Raleigh, N. C., J. J. Ahern, W. N. Cox, G. H., Dunstan, P. N. Lehoczky, J. H. Mathewson, W. F. O'Connor, N. A. Parker, J. F. Piccard, J. C. Stennett, J. K. Walkup.

JAMES H. MCGRAW AWARD: H. P. Rodes, *Chairman,* University of California, Los Angeles, Calif.; for two years, K. L. Holderman, L. V. Johnson, C. S. Jones; for one year, J. T. Faig, C. J. Freund, H. P. Rodes; *Ex-Officio,* E. E. Booher, F. M. Dawson, H. P. Adams.

JUNIOR COLLEGES: H. P. Rodes, *Chairman,* University of California, Los Angeles, Calif., D. E. Deyo, *Vice Chairman,* L. L. Bethel, N. L. Gates, J. Gerardi, R. W. Marsh, L. L., Medsker, R. G. Moses.

LAMME AWARD: N. W. Dougherty, *Chairman,* University of Tennessee, Knoxville, Tenn.; for four years, M. M. Boring, M. P. O'Brien, B. R. Teare; for three years, N. W. Dougherty, R. E. Doherty, W. K. Lewis; for two years, H. P. Hammond, A. A. Potter, W. C. White; for one year, E. D. Ayres, F. Kerekes, G. A. Stetson.

MEMBERSHIP: F. M. Dawson, *Chairman,* State University of Iowa, Iowa City, Ia. *State Chairmen:* J. E. Hannum, Alabama; E. S. Borquist, Arizona; G. F. Branigan, Arkansas; R. E. Vivian, California; T. H. Evans, Colorado; H. J. Lockwood, Connecticut; A. P. Colburn, Delaware; C. H.

Walter, District of Columbia; R. A. Morgen, Florida; F. W. Ajax, Georgia; H. W. Silha, Idaho; J. T. Retalliata, Illinois; F. C. Hockema, Indiana; F. Kerekes, Iowa; W. H. Honstead, Kansas; D. V. Terrell, Kentucky; R. T. Sessums, Louisiana; W. S. Evans, Maine; C. O. Terwilliger, Maryland; G. A. Marston, Massachusetts; C. L. Brattin, Michigan; N. A. Hall, Minnesota; H. V. Flinsch, Mississippi; H. Rubey, Missouri; E. R. Dodge, Montana; W. L. DeBaufre, Nebraska; H. B. Blodgett, Nevada; J. J. Ermenc, New Hampshire; K. H. Condit, New Jersey; M. A. Thomas, New Mexico; J. R. Dunning, P. E. Hemke, New York; R. E. Fadum, North Carolina; L. C. Harrington, North Dakota; R. D. Landon, Ohio; R. L. Langenheim, Oklahoma; R. A. Wanless, Oregon; K. L. Holderman, Pennsylvania; E. M. Pease, Rhode Island; A. Berne-Allen, South Carolina; E. D. Dake, South Dakota; R. M. Boarts, Tennessee; L. B. Ryon, Texas; J. Coulam, Utah; J. A. Bullard, Vermont; R. M. Hubbard, Virginia; H. E. Wessman, Washington; W. A. Koehler, West Virginia; R. A. Ragatz, Wisconsin; H. T. Person, Wyoming; K. F. Tupper, Canada; P. L. Carroll, Mexico; A. R. Hellwarth, Industrial.

COORDINATING COMMITTEE ON RELATIONS WITH THE FEDERAL GOVERNMENT: T. Saville, *Chairman*, New York University, New York, N. Y., T. H. Evans, G. W. Gleeson, D. B. Prentice, A. F. Spilhaus, G. Lobinger, W. R. Woolrich, F. M. Dawson, *Ex-Officio*.

SECTIONS AND BRANCHES: H. H. Armsby, *Chairman*, U. S. Office of Education, Washington, D. C., M. T. Ayers, M. P. Capp, W. H. Carson, David S. Clark, W. L. DeBaufre, M. E. Farris, R. S. Glasgow, W. A. Koehler, R. D. Landon, E. R. McKee, L. G. Miller, G. K. Palsgrove, L. O. Stewart, H. H. Wheaton, R. Z. Williams.

YOUNG ENGINEERING TEACHERS: (Interim Committee), D. L. Trautman, *Chairman*, University of California, Los Angeles, Calif., D. Bergh, S. A. Duran, L. W. Gleekman, V. B. Hammer, T. J. McClellan, F. L. Schwartz, G. C. Szego, G. C. Wilson.

REPRESENTATIVES OF THE SOCIETY ON VARIOUS COMMITTEES, BOARDS, AND COMMISSIONS:

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: Council representatives: W. R. Woolrich (1951), J. R. Van Pelt (1951).

AMERICAN COUNCIL ON EDUCATION: A. B. Bronwell (1953), H. T. Heald (1952), S. S. Steinberg (1951).

AMERICAN STANDARDS ASSOCIATION:

Z10—Symbols and Abbreviations: W. A. Lewis, *Chairman*, T. C. Hanson, P. J. Kiefer, W. B. Plank, M. C. Stuart, C. C. Whipple.

Z14—Drawings and Drafting Room Practice: H. C. Spencer, *Chairman*, F. G. Higbee, R. P. Hoelscher, W. J. Luzadder, R. S. Paffenbarger, C. L. Svensen, C. J. Vierck.

Z15—Graphic Presentation: R. S. Paffenbarger, *Chairman*, D. P. Adams, A. S. Levens, R. O. Loving.

Z32—Graphical Symbols and Drawings: I. L. Hill, *Chairman*, J. G. McGuire, R. T. Northrup.

A62—Coordination of Dimensions of Building Materials and Equipment: R. A. Caughey.

C61—Electric and Magnetic Magnitudes and Units: Harold Pender, C. V. O. Terwilliger, C. F. Rehberg.

CHARLES A. COFFIN FELLOWSHIPS AND RESEARCH COMMITTEE: F. M. Dawson.

EDUCATIONAL TESTING SERVICE, ADVISORY COUNCIL: H. R. Beatty, O. W. Eshbach, F. M. Dawson, *Ex-Officio*.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT: W. R. Woolrich (Oct. 1952), H. T. Heald (Oct. 1951).

ENGINEERS JOINT COUNCIL:

COMMITTEE ON UNITY IN THE ENGINEERING PROFESSION: T. Saville.

GENERAL SURVEY COMMITTEE: M. M. Boring.

COMMITTEE ON SURVEY OF TECHNICAL MANPOWER NEEDS: F. M. Dawson, H. H. Armsby, Thorndike Saville.

ENROLLMENT STATISTICS (Joint Committee with U. S. Office of Education): H. P. Hammond, *Chairman*, A. B. Bronwell, G. D. Lobingier.

NATIONAL BUREAU OF ENGINEERING REGISTRATION (Advisory Board): N. W. Dougherty.

NATIONAL RESEARCH COUNCIL: F. M. Dawson, G. A. Rosselot.

Divisions, 1950-51

AERONAUTICAL: W. C. Nelson, *Chairman,* University of Michigan; A. E. Cronk, *Vice Chairman;* C. N. Sanford, *Secretary;* H. W. Barlow, *Member of Council,* 1951.

AGRICULTURAL: H. J. Barre, *Chairman,* Purdue University; A. W. Farrall, *Vice Chairman;* O. C. French, *Secretary.*

ARCHITECTURAL: L. R. Blakeslee, *Chairman,* University of Detroit; W. W. Dornberger, *Vice Chairman;* P. E. Soneson, *Secretary;* S. A. Smith, *Member of Council,* 1952.

CHEMICAL: J. S. Walton, *Chairman,* Oregon State College; N. H. Ceaglske and G. C. Williams, *Vice Chairmen:* R. L. Savage, *Secretary;* R. A. Ragatz, *Member of Council,* 1951.

CIVIL ENGINEERING: Harry Rubey, *Chairman,* University of Missouri; E. H. Gaylord, *Vice Chairman;* F. W. Stubbs, *Secretary;* H. W. Wood, *Editor, CE Bulletin; Directors:* W. L. Moore, F. W. Stubbs, A. A. Jakkula, W. Raeder; W. M. Lansford, *Member of Council,* 1952.

COOPERATIVE ENGINEERING EDUCATION: D. C. Hunt, *Chairman,* University of Detroit; H. R. Bintzer, *Vice Chairman;* A. O. Taylor, *Secretary;* M. B. Robinson, *Member of Council,* 1951.

EDUCATIONAL METHODS: F. H. Pumphrey, *Chairman,* University of Florida; H. R. Beatty, *Vice Chairman;* G. S. Speer, *Secretary;* E. A. Walker, *Member of Council,* 1952.

ELECTRICAL: T. H. Morgan, *Chairman,* Worcester Polytechnic Institute; F. O. McMillan, *Vice Chairman;* H. E. Hartig, *Secretary;* G. B. Hoadley, *Member of Council,* 1951.

ENGINEERING DRAWING: R. S. Paffenbarger, *Chairman,* Ohio State University; C. H. Springer, *Secretary; Executive Committee:* J. G. McGuire, W. E. Street, C. E. Rowe, H. E. Grant, R. S. Paffenbarger; T. T. Aakhus, *Editor;* J. Gerardi, *Editor, T-Square Page;* C. J. Vierck, *Advertising Manager:* W. J. Luzadder, *Circulation Manager;* H. C. Spencer, *Member of Council,* 1952.

ENGLISH: J. H. Pitman, *Chairman,* Newark College of Engineering; G. J. Christensen, *Vice Chairman,* and *Secretary;* R. L. Shurter, *Member of Council,* 1951.

EVENING ENGINEERING EDUCATION: S. E. Winston, *Chairman,* Illinois Institute of Technology; L. W. Krogh, *Vice Chairman;* H. Torgersen, *Secretary,* H. R. Beatty, *Member of Council,* 1951.

GRADUATE STUDIES: J. H. Rushton, *Chairman,* Illinois Institute of Technology; A. Colburn, *Vice Chairman;* C. O. Harris, *Secretary; Directors:* H. L. Solberg, G. B. Hoadley, N. J. Hoff, D. F. Peterson, H. E. Wessman; J. H. Rushton, *Member of Council,* 1952.

HUMANISTIC-SOCIAL STUDIES: S. W. Chapman, *Chairman,* University of Washington; C. W. Condit, *Secretary; Executive Board:* H. R. Bartlett, P. E. Mohn, J. W. Shirley, Hallett Smith, B. R. Teare, F. L. Wilkinson; J. E. Thornton, *Member of Council,* 1951.

INDUSTRIAL ENGINEERING: H. R. Beatty, *Chairman,* Pratt Institute; J. A. Apple, *Vice Chairman;* W. G. Ireson, *Secretary;* E. Laitala, *Member of Council,* 1952.

MATHEMATICS: W. C. Krathwohl, *Chairman,* Illinois Institute of Technology; J. H. Zant, *Secretary; Directors:* F. H. Miller, C. R. Wylie, Jr., D. F. Gunder; H. K. Justice, *Member of Council,* 1951.

MECHANICAL ENGINEERING: L. C. Price, *Chairman,* Michigan State College; H. Kuenzel, *Vice Chairman;* E. L. Midgette, *Secretary;* H. A. Bolz, *Member of Council,* 1952.

MECHANICS: R. G. Sturm, *Chairman,* Purdue University; *Executive Board:* S. Ward, G. W. Smith, W. M. Lansford, R. G. Sturm, G. Murphy, A. L. Miller, J. Marin, G. H. MacCullough; E. C. Clark, *Member of Council,* 1951.

MINERAL ENGINEERING: H. H. Power, *Chairman,* University of Texas; A. Butts, *Vice Chairman;* W. J. Rundle, *Secretary;* T. L. Joseph, *Member of Council,* 1952.

PHYSICS: E. Hutchisson, *Chairman,* Case Institute of Technology; F. G. Slack, *Vice Chairman;* G. P. Brewington, *Secretary; Executive Board:* J. G. Potter, H. L. Dodge, M. W. White; C. E. Bennett, *Member of Council,* 1951.

RELATIONS WITH INDUSTRY: B. R. Teare, *Chairman,* Carnegie Institute of Technology; M. J. Bergen, *Vice Chairman;* E. N. Baldwin, *Secretary-Treasurer; Executive Committee Directors:* For three years: E. M. Baldwin, J. F. Downie

Smith, D. S. Bridgeman; for two years: E. C. Koerper, M. J. Bergen, B. R. Teare, Jr.; for one year: J. C. McKeon, Jr., C. J. Freund, K. B. McEachron, Jr.; J. C. McKeon, Jr., *Member of Council,* 1951.

TECHNICAL INSTITUTE: H. P. Adams, *Chairman,* Oklahoma A. & M. College; K. O. Werwath, *Vice Chairman;* H. P. Rodes, *Secretary;* K. L. Holderman, *Member of Council,* 1951.

Sections, 1950-51

ALLEGHENY: D. F. Miner, *Chairman,* Carnegie Institute of Technology; E. B. Stavely, *Vice Chairman;* J. W. Graham, Jr., *Secretary;* W. A. Koehler, *Member of Council,* 1951.

ILLINOIS-INDIANA: W. C. Knopf, *Chairman,* Northwestern University; D. G. Ryan, *Vice Chairman;* C. E. Watson, *Secretary; Executive Committee:* D. S. Clark, R. M. Ross, H. P. Hall, R. N. Shreve, C. C. Stevason, E. Danner, B. A. Fisher; D. S. Clark, *Member of Council,* 1952.

KANSAS-NEBRASKA: F. W. Norris, *Chairman,* University of Nebraska; Wilson Tripp, *Vice Chairman;* A. S. Andes, *Secretary-Treasurer;* W. L. DeBaufre, *Member of Council,* 1951.

MICHIGAN: H. M. Dent, *Chairman,* General Motors Institute; W. P. Godfrey, *Vice Chairman;* F. L. Schwartz, *Secretary-Treasurer;* L. G. Miller, *Member of Council,* 1952.

MIDDLE ATLANTIC: C. H. Willis, *Chairman,* Princeton University; G. B. Thom, *Vice Chairman;* William Allan, *Secretary-Treasurer;* M. T. Ayers, *Member of Council,* 1951.

MISSOURI: R. J. W. Koopman, *Chairman,* Washington University; I. H. Lovett, *Vice Chairman;* J. R. Lorah, *Secretary;* R. Z. Williams, *Member of Council,* 1951.

NATIONAL CAPITAL AREA: R. B. Allen, *Chairman,* University of Maryland; W. Oncken, *Vice Chairman;* L. K. Downing, *Secretary-Treasurer;* R. S. Glasgow, *Member of Council,* 1952.

NEW ENGLAND: W. C. White, *Chairman,* Northeastern University; W. E. Keith, *Secretary;* E. R. McKee, *Member of Council,* 1951. (New officers to be elected in October, 1950).

NORTH MIDWEST: E. W. Johnson, *Chairman,* University of Minnesota; K. F. Wendt, *Vice Chairman;* A. O. Lee, *Secretary; Executive Board:* L. A. Ware, S. J. Chamberlain, R. J. Panlener, George Swenson, A. W. Anderson; L. O. Stewart, *Member of Council,* 1952.

OHIO: W. F. Brown, *Chairman,* University of Toledo; S. M. Marco and P. L. Rea, *Vice Chairman;* L. D. Jones, *Secretary;* R. D. Landon, *Member of Council,* 1951.

PACIFIC NORTHWEST: A. S. Janssen, *Chairman,* University of Idaho; C. O. Reiser, *Vice Chairman;* Paul Mann, *Secretary;* O. E. Osburn, *Member of Council,* 1950.

PACIFIC SOUTHWEST: E. D. Howe, *Chairman,* University of California, Berkeley; S. F. Duncan, *Vice Chairman;* R. G. Moses, *Secretary-Treasurer; Executive Committee:* H. B. Blodgett, C. T. Reid, R. J. Smith; H. H. Wheaton, *Member of Council,* 1951.

ROCKY MOUNTAIN: J. E. Christiansen, *Chairman,* Utah State College; E. J. Lindahl, *Vice Chairman;* F. Preator, *Secretary;* M. P. Capp, *Member of Council,* 1952.

SOUTHEASTERN: E. B. Norris, *Chairman,* Virginia Polytechnic Institute; R. L. Sumwalt, *Vice Chairman;* B. M. Bayer, *Secretary-Treasurer;* F. J. Lewis, *Member of Council,* 1951.

SOUTHWESTERN: R. L. Peurifoy, *Chairman,* Texas A. & M. College; H. P. Adams, *Vice Chairman;* M. R. Lohmann, *Secretary-Treasurer; Executive Board:* L. B. Ryon, R. M. Wingren, C. E. Rowe, H. W. Crate, R. L. Langenheim, C. T. Grace; W. H. Carson, *Member of Council,* 1952.

UPPER NEW YORK: F. H. Thomas, *Chairman,* University of Buffalo; W. H. Allison, *Vice Chairman;* A. D. Taylor, *Secretary-Treasurer;* G. K. Palsgrove, *Member of Council,* 1952.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Kansas-Nebraska	Kansas State College	Oct. 13–14, 1950	F. W. Norris, University of Nebraska
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Stevens Institute of Technology	Dec. 9, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	Naval Ordnance Laboratory	Oct. 3, 1950 Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	University of New Hampshire	Oct. 14, 1950	W. C. White, Northeastern University
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13 & 14, 1950	F. H. Thomas, University of Buffalo

Members of the Society are welcome at all Section Meetings

The Nature of Engineering

By MORROUGH P. O'BRIEN

Dean, College of Engineering, University of California, Berkeley

There have been many attempts to define engineering and it is, perhaps, presumptuous to formulate another definition. However, the planning and accreditation of engineering curricula and the registration of engineers have developed an increasingly urgent demand for a generally accepted formulation of the nature of engineering and of the qualifications to be expected of engineers. The Committee on Engineering Schools of the Engineers Council for Professional Development has proposed, tentatively, a definition which almost meets the need but which, in my opinion, may be improved somewhat. My proposal is as follows:

> The activity characteristic of professional engineering is the design of structures, machines, circuits, or processes, or of combinations of these elements into systems or plants and the analysis and prediction of their performance and costs under specified working conditions. Professional engineers are persons qualified to engage in this activity.

This statement impresses, many engineers as being unduly restrictive. It has been formulated in an effort to discern the sine quo non which characterizes engineering as a profession and to exclude the many other activities in which professional engineers engage successfully. Another approach, which is fallacious and misleading, is to develop the scope of engineering from an examination of the work of individuals who are evidently competent professional engineers. The boundaries of the profession thus described are vague and include many other occupations. The terminology employed in this statement requires explanation and its general intent should be clarified by examples.

Engineering Functions

The word "design" is employed here in the broad sense of planning but includes the more restricted meaning implied by such terms as machine design or bridge design. The general layout of a factory, mine, irrigation system, or power plant and the selection of suitable equipment are design just as much as the necessary calculations and drawings, and in fact, represent the higher levels of this function. Furthermore, one might expand the definition to include in the meaning of "design," the prediction of performance and cost, thus making the second half of the statement redundant; but in view of the more restricted sense in which "design" is so frequently used, this amplification seems desirable.

If design is the characteristic activity, what may be said about the other functions frequently listed as falling within the scope of engineering, such as research, teaching, production, construction, maintenance, sales, and others. The definition excludes them on the ground that they are not inherently characteristic even though many engineers engage in them successfully.

Consider, for example, the sales engineer who analyzes a customer's requirements, compares these requirements with the characteristics of his product, and makes a recommendation, supported by an analysis of costs. He performs an engineering function in the strict sense of the definition but it does not follow that all salesmen of technical products

should be classified as engineers.. Many professional engineers engage in research and teaching but it does not follow that anyone is to be classified as an engineer if the person engages either in teaching subjects basic to engineering practice or in research contributing to the solution of engineering problems. Planning a construction plant and the related flow of materials and predicting the construction costs is an engineering function but the direction of large scale construction operations does not ipso facto qualify a man as a professional engineer. It is because these, and other functions frequently mentioned as being within the scope of engineering, do offer opportunities for engineering practice in the strict sense of the term that professional engineers, in ever increasing numbers, engage in them.

Management is frequently mentioned as an engineering function because the design of the production methods and the design of the organization which is to carry out these methods is as important as the design of the machines. In this restricted sense, management would qualify as an engineering function under the definition proposed because the performance and costs of the individual machines, circuits, structures or processes, and of the overall productive system, including labor costs and labor productivity, would be involved in the design of an organization intended to carry on a technical activity. However, management is used in a broader sense and generally pertains to the direction of an organization. The design of an airline maintenance base, requiring an analysis of the components to be inspected and repaired and the cost of these operations, should be included, but the construction and the management of such a base are not inherently engineering activities.

The element of cost in the definition requires attention. In order to predict the initial or operating costs, the wages and productivity of labor must be known and this brings into the problem the results of many specialized activities such as cost accounting, time and motion study, and so forth. To the extent that planning, analysis, and prediction are involved, industrial engineering qualifies as a branch of engineering within the definition, but cost accountants, motion study experts, and the many other specialists engaged do not thereby qualify as engineers.

Diversified Character of Engineering

Reviewing the many restrictions mentioned, the question may well arise as to whether anyone practices engineering. The answer is that engineering has become predominantly a group activity in which a single individual seldom carries through all the characteristic components at any stage of his career. Through education and experience one becomes qualified to "analyze and predict performance and cost" but only rarely does one individual carry through all the steps implied.

Engineering educations aim primarily at providing a basis for the quantitative and scientific aspects of the analysis and prediction of performance. A start is usually made in the direction of analyzing and predicting costs, but progress in college is not sufficient for professional practice. Experience is necessary to round out the individual's capacity for prediction of performance, especially of systems involving men as well as machines, and of costs. The best test of the qualifications to carry on engineering work in the sense defined is the actual doing of such work, usually in a sequence of assignments carrying increasing responsibilities for planning and prediction.

No mention is made in the definition proposed of such terms and phrases as "art and science," "use and convenience of man," or "the engineering method." This omission does not imply any lack of appreciation of the importance of professional ethics, services to mankind, or other aspects of professional practice. The aim has been to define that activity characterizing engineering and to strip

away everything else. Without this activity, there would be no engineering profession. Artesans are concerned with machines, circuits, structures and processes. Business men are concerned with costs and with management. Some physiologists and psychologists are concerned with the effect of machines on men. A certain aspect of these subjects, namely, design, analysis, and prediction, is characteristic of engineering. Only those individuals who are qualified to engage in this characteristic activity are engineers.

This discussion may be concerned with a fine distinction having no practical importance. Many words have been written on it without providing a clear cut basis for such practical matters as the registration of engineers, and perhaps a simple way of ending the discussion is to say that engineers are persons who are registered as such. Perhaps the distinction between engineering and what engineers do might be illustrated by reference to another profession, pharmacy. If one undertakes to describe pharmacy in terms of what pharmacists do, a visit to the corner drugstore would produce the conclusion that they are primarily managers or salesmen in small enterprises engaged in the sale of cigars, magazines, cosmetics, stationery, and so forth. One might add that they follow a special "pharmaceutical" method in the display of their wares, that they perform a public service, and that occasionally they fill medical prescriptions. This statement might be realistic, but it would not provide a basis for the registration of pharmacists or a guide to the best method for their education. The confusion regarding the nature of engineering stems from the same cause, namely, definition in terms of the work of men educated in engineering schools.

A definition should not set up a barrier to the acceptance of positions, nor should it set a limit on the programs of engineering schools. Engineers have been successful in many fields, and particularly in research, teaching, production, construction, sales and so forth, and there is no reason why engineering schools should not continue to consider these employment opportunities in planning curricula and advising students. However, these sidelines should be treated as such and should not become the principal objective.

Science and Engineering

There exists a difference in viewpoint and purpose between the engineer and the scientist which is basic and essential. The similarity in subject matter presented in their formal education has tended to obscure this fact, especially in the minds of many professors of both science and engineering, and it is of the greatest importance that this divergence be clearly understood. Chemists, geologists, mathematicians, and physicists differ from engineers not in the distance which they have traveled along the road of science. They have moved along a different road entirely, and one which bears only a superficial resemblance to that followed by the engineer. The road surface and other details of construction are sufficiently alike to confuse a stranger unfamiliar with the terrain but there the similarity ends. Failure to recognize that there are really two roads leading in different directions can only result in wasted effort and confusion. True, the two roads diverge gradually and there are cross-connections between them, but the fact remains that they lead to different destinations.

The activity characteristic of engineering has been defined. A similar treatment of the nature of science is difficult to formulate, especially for an engineer, but the differences between them pertinent to this discussion may be brought out by some quotations and examples.

In an address before the British Association for the Advancement of Science, R. V. Southwell[1] made the following statement:

[1] R. V. Southwell, F.R.S., Presidential address before Section G, 1938. Reported in *Engineering*, August 26, 1938.

"Wherein, then, does the outlook of the engineer differ from that of the physicist? Mainly, I think, in that his problems are inexorable, and he recognizes them as such. The physicist, despairing of progress along a path attempted, is free to try some other. The engineer has to solve the problem as it is presented, and some solution he must have, even though it be only approximate.

"Now uncertainty of this kind does not enter into the physicist's scheme of things at all. The physicist's problems are fundamental, and he is not the man to let them be complicated by additional difficulties. If corrosion is a potential source of trouble, then he will use gold if need be; if magnetic flux is calculable only for one or two particular shapes, then he will use those shapes. Because throughout he is free to choose; his shapes are not dictated by constructional or manufacturing requirements, nor his materials by considerations of strength or cost.

"Simple illustrations are best. Let us visualize the attitude to elasticity of a physicist who still retains some interest in Nineteenth-Century physics. He will be interested in Hooke's law, and in its interpretation as a statistical average of effects due to forces from very many atoms. He will recognize two distinct types of strain, the first involving change of dimensions without change of shape, the second change of shape without change of volume, and he will devise ingenious experiments for measuring the two relevant elastic moduli. In this connection he will study Saint-Venant's theory of torsion and of flexure, and he may even pursue the harder parts of elastic theory with the aim of eliminating errors in measurement that result from straining due to weight. But speak to him of the strength and distortion of an engine crankshaft—a matter of interest in practice, so long as engines tend to fail by torsional vibration; and if you find him interested then—well, he is an engineer in disguise! For speaking qua physicist he will say: "I see that both torsion and flexure are involved—that is, both of the two fundamental types of strain, but why study these in a body of such appalling shape?" And the engineer can only reply: "Because I must. This shape was not evolved for its intrinsic interest, but its strained form is important none the less —and very difficult to calculate."

One need not conjure up hypothetical examples to illustrate this difference in viewpoint. We have all experienced the complexity of engineering problems and the inadequacy of scientific principles and mathematical methods to their solution.

It is the purpose of science to seek out generalizations pertaining to natural phenomena, and this purpose would not be well served if considerations of utility entered into the choice of subjects for investigation. The progress of science has demonstrated that the most important advances have been made by men impelled only by curiosity and without thought of practical application. Science should hold firm to this viewpoint and should not be deflected by the glamour or the availability of funds on the side of practical applications.

My comments thus far have been directed towards what is sometimes termed "pure science," the word "pure" connoting, apparently, freedom from the taint of utility. We should now give consideration to the engineering sciences, such as dynamics, elasticity, fluid mechanics, heat transfer, mass transfer, metallurgy, combustion, and others. In substance, the subject matter of these fields may be classified somewhere under chemistry, mathematics, or physics: but they have lost in large measure their appeal to the pure science departments of the universities and colleges. Some individual scientists, principally in the smaller science departments, carry on work in these subjects, but the attitude generally seems to be that they are no longer fruitful fields for scientific endeavor, or at least that they are not worthy of the efforts of first-class scientists.

The scientist idealizes and simplifies his problem by assuming in his theory, and realizing as far as possible in his experiments, simple geometry, frictionless fluids, reversible reactions, masses concentrated at a point, isotropic materials, and so forth. This approach has been fruitful in yielding the many generalizations of science but the effort stopped short of providing analytical tools for the solution of engineering problems.

A classical example is the huge gap

between theoretical hydrodynamacis and practical hydraulics which existed until very recent years. During the eighteenth and nineteenth centuries, mathematicians and physicists developed theoretical hydrodynamics almost to its present state, but the results predicted by this theory were so completely at variance with experience that the hydraulic engineer developed his design procedures on a purely empirical basis. The theoretical results were correct for the conditions assumed but these conditions were not encountered in engineering practice.

Aeronautical engineering, with its requirement of low resistance and weight, provided the stimulus for the investigations, both theoretical and experimental, which have extended classical hydrodynamics so as to contribute to the solution of engineering problems. It should be noted that it was the spur of a deficiency of design data and methods which led to the rapid expansion of the engineering science of aerodynamics and not the exploratory urge of the pure scientist.

Evolution of Engineering

Engineering developed first as an art, dependent chiefly on judgment and experience, and developed the scientific side later not because engineers were incapable of understanding science but because scientific principles proved almost useless in solving engineering problems. Progress was made in small steps, using the experience gained on one successful development to forecast the behavior of another slightly larger or different. The money involved made drastic innovation dangerous. Failures were carefully studied to indicate their causes. This empirical attitude led to the development of methods of model-testing as a means of gaining useful generalizations, and as insurance against the failure of particular designs. The model scaling laws, required for the transference of experimental data to a prototype of different size or one operated under different conditions, brought into consideration many of the generalizations previously established in pure science. Success in this limited application of scientific principles led to further efforts in the same direction.

The basic problem was, of course, that in the usual engineering problem many variables operated simultaneously, and even the boundary conditions were too complex for analytical treatment. At present, the gap between basic science and engineering design is being closed in many of the engineering sciences by working forward from pure science and backward from the tests of working units, but there remains much to be done in all of them. The requirements of engineering design have provided the stimulus and and the support for these important studies which are an essential link in the process of applying the results obtained by the basic sciences.

Science, either pure or applied, is not likely to result directly in profitable developments and industry cannot justify substantial participation in it. In spite of the implications of some publicity, only a few large companies engage in research at their own expense, and such as they do is usually directly related to a development problem. Some government laboratories, such as the Bureau of Standards, do engage in research in both the pure and engineering sciences, but their principal efforts are directed at development work, frequently for military purposes. The principal burden for research in science falls upon the educational institutions; and, as regards the engineering sciences, the responsibility is, in my opinion, clearly that of the engineering schools. It is only in recent years that this responsibility is being realized, and far too few engineering schools have taken steps to meet it. The post-war upsurge of foundations sponsored by engineering schools has been directed too much at development work and too little at the extension of the engineering sciences. The deficiency in these areas is great and it is to be hoped that the newly established National Science Foundation will provide the stimulus and some of the support for a more intensive effort.

The individuals working in the engineering sciences have essentially the same viewpoint and follow the same methods as their colleagues in the pure sciences. Many of them received their undergraduate and graduate training in the pure sciences, while others came up through the engineering curricula and later found that their interests lay in science rather than engineering practice. The difference between these scientists and the pure scientist lies in the fact that the general area of investigation is selected with a view to engineering applications and their environment is one likely to maintain this interest.

Historically, the stimulus for the development of the engineering sciences has come from the needs of engineering practice, and there is some danger that groups working in these fields will lose their drive by becoming isolated from practice. An engineering school should include in its faculty men whose interests range from science to engineering practice; and when this situation is achieved, there will be a two-way transmission of ideas and methods, practice stimulating the engineering sciences with its problems and these sciences supporting practice with their results.

The Function of the Engineer in Society

In "America's Needs and Resources"[2] the productivity of labor and it relationship both to machine power and to real income is summarized as follows:

SOURCES OF POWER IN INDUSTRY

Year	Men	Animals	Mach	Goods (1940) per Hr
1850	15%	79%	6%	$0.27
1900	10	52	38	.56
1930	4	12	84	.82
1960 (interpolated)	3	1	96	1.61

[2] Twentieth Century Fund. Macmillan, New York, 1949.

The goods per hour are corrected to 1940 prices and are a measure of the return for one hour of productive effort. In the period 1850 to 1940, the average industrial working week was reduced from 72 to 43 hours.

Through the design of machines, circuits, structures, and processes, engineers provide the means by which the productivity of labor is increased and the genaral standard of living raised. Many other groups participate in this process and there is no implication intended as to the relative importance of engineers and others in this respect. However, it is true that the efforts of engineers, using engineer in the sense of the definition, are directed almost solely towards increasing productivity or reducing the cost of essential goods and services and, thus, towards making possible a higher standard of living.

Engineers should understand this function which they perform in society and should be aware of, and as a group work to influence, the policies and laws which tend to expand or circumscribe his activities. Engineering works, and the beneficial effects which they produce, require capital expenditures and a steady flow of capital, public and private, is essential to continued engineering activity. Tax laws, depreciation policies, real wages, interest rates, and many other factors influence the availability of capital for these purposes. As an example of the type of major problem, in which engineers may play a part, either individually or as a group, is the present paradoxical situation of rising unemployment in a period of prosperity. Labor productivity has been rising rapidly since the war and the volume of goods and sciences required by a growing population is being supplied by an almost constant working force. Unemployment is growing because the increase in employables is not being absorbed. You may well ask what can engineers do about such a problem. I will not discuss the question in detail, but I will give two examples. In California, the ceramics industry is small but grow-

ing, and it appeared that some assistance through research and development might yield substantial results. To provide a background for this program, a study was made of the invested capital per job in this industry and it was found that the ceramics industry required approximately $3,000 per job as compared with $30,000 per job in certain branches of the chemical industry and $8,000 per job in industry as a whole. This result showed that, to the extent that additional production of ceramic materials is needed, investment there would produce more jobs than in almost any other technical industry.

Another example, and one on a national scale, is the work of the Water Policy Panel of the Engineers Joint Council which is studying the desirable policies and criteria of the Federal government regarding water projects, irrigation, flood control, navigation, power, drainage, water supply, and so forth. The objective is to develop criteria for the appraisal of the benefits of these projects and for the allocation of costs. For engineers generally, the importance of this work lies in the fact that money spent on such projects must ultimately be derived from taxes on individuals and corporations. If not collected in taxes and so spent, it would become potentially available for investment in other productive facilities. The decision as to extent to which the Federal government should participate in these water projects should depend upon the extent of the benefits derived, and it is primarily the engineer who is responsible for appraising these benefits. If this appraisal is realistic and complete, it will provide a basis for comparing their effect on productivity and on the general welfare with other potential investments. Each water project is using capital which might be used to build chemical plants, steel mills, highways, and other works. The engineering profession is in a position to aid materially in this matter by providing both reliable and uniform methods of appraisal and facts regarding the effect of alternative investments.

Engineering Education

The practice of engineering involves as much of art as of science, and the art of engineering is best acquired through experience. Consequently, the young engineer should come to grips with practical problems at as early an age as possible without, however, sacrificing essential education. This situation has resulted in the general acceptance of a basic four-year program as the usual education of an engineer. Some schools have shifted the beginnings of practical experience down to the early years of the curriculum by means of the co-operative program, and this appears to be an effective arrangement. Those graduates who practice engineering, within the meaning of the definition given in this paper, probably should spend one or more years in graduate study preparatory to professional practice; but with or without graduate study, continued study will be necessary for them.

It is not my intention to discuss curricula as such, but only to make a few general observations on matters which I feel, have not been sufficiently stressed in many discussions of engineering education.

Engineers are concerned with the expenditure of capital for equipment and plants. Their employees, whether public or private, authorize the expenditures in the expectation of realizing both the predicted performance and the predicted operating costs. Excessive costs or deficiencies in performance have resulted from plans based on theoretical analyses, from undue interpolation of past experience, from unpredicted difficulties with foundations and materials, and many other causes. The obvious result is a very conservative attitude on the part of the professional engineer towards innovation and change. Defects frequently do not appear for years and a cautious, waiting attitude is adopted towards new developments. All this is fitting and proper because of the responsibility of the engineer for the investment of capital.

As regards engineering education, the

problem is to instill in the minds of the student a deference for experience and good practice without at the same time closing his mind to innovation and change. It is a dilemma of major importance, and I have no solution to offer except the suggestion that engineering courses keep to a minimum the attention to established design procedures, which the graduate will easily acquire on the job if his general background is good. However, it is also important that the engineering schools continue to emphasize the importance of experience and sound judgment.

Another aspect of the practice of engineering which has a bearing on engineering education is that it has become a group activity. Extreme individualists may find their niche in engineering but, in general, the engineer must fit into a team. The usual engineering curriculum, with its group work in laboratories, serves both to test and to develop this attitude, but the general pressure of the engineering curriculum leaves too little time for campus activities and social affairs, which will do more than any possible selection of courses to develop the understanding of men necessary for group endeavor.

A third aspect of the practice of engineering, which has a bearing on engineering education is the attitude of the engineer towards the job to be done. The scientist is free to work on the problem which interests him and, if he loses interest, he can choose another. The engineer must work on the job assigned and the sooner he acquires the viewpoint that the most interesting and important job is the one which *must* be done, the happier and more fruitful will be his professional life. This motivation and stimulus of the need for a solution of a problem posed by others is most important and the beginnings of it should be developed in the engineering school. These remarks are not intended to imply that an engineering student should not explore fully his interests and aptitudes or that practicing engineers must become automatons; rather the engineer, after finding the niche which suits him best, should attack each problem assigned with all the zest and enthusiasm that he would if he chose the problem himself and I think the engineering program of study helps to develop this viewpoint through the emphasis on laboratory experiments and problems.

The essence of these comments is that engineering education presents two paradoxical requirements, namely, (1) that individuality and imagination must be preserved in students who must also be prepared for group activity, and (2) that open-mindedness towards innovation must be developed along with respect for value of experience and precedent. These problems are, I think, common to all types of professional education. They are acute in engineering education because engineering has generally retained, for good reason, the four-year period of basic training.

Process Engineering

In his address at the Chemical Engineering Congress at London in 1936,[3] George Granger Brown stated:

> "Although the term mechanical engineer and electrical engineer may be interpreted as indicating the type of energy with which the engineer deals, so much of chemical engineering is physical as well as chemical that it often appears that the expression "Process Engineering" might be a more pertinent designation for what we now know as chemical engineering. Analysis of the types of operations conducted by so-called chemical engineers indicates that those operations most commonly encountered are mainly physical in nature."

This term, if it had been generally applied, would have obviated many of the difficulties which have attended the development of chemical engineering as a branch of engineering profession. I shall use the term process engineering in this discussion.

The process engineer designs or selects the machines, equipment, and materials and arranges them in a system in order

[3] Trans. Chem. Eng. Congress of World Power Conference, Vol. IV, p. 122, Percy Lund, Humphries & Co., London, 1937.

to control the environment of a chemical or physical process so as to achieve the predicted output at minimum cost.

Process engineering came to separate professional status after civil, electrical, and mechanical, and it missed that early phase of the development of the other branches of the profession in which art, or judgment based on intuition and experience, was the predominant influence. By the time process engineering was recognized as a separate branch of engineering through the establishment of curricula for the education of process engineers, the number of physical and chemical processes falling within the cognizance of process engineers was so great that a knowledge of the art of each was clearly impossible. Science and engineering science had progressed to a point such that the field could be broken down into unit operations and unit processes and the educational program was thus simplified. You are more familiar with this historical development than I am and I summarize it briefly only as a prelude to my comments on the relationship between process engineering and the other curricula.

Frequently, when I am asked to explain my conception either of the nature of engineering or of the desirable end point of an engineering curriculum, I turn to the annual prize problems of the American Institute of Chemical Engineers as the most compact and clear-cut example representative of my views. These problems vary in character and scope from year to year. In general they exemplify the nature of engineering as here defined in that they apply science and engineering science to the prediction of performance and cost and, from the standpoint of the educational process, they synthesize the preceding courses of instruction in an effective manner.

One point at which I am at odds with the typical curricula in this field is that the major unit processes of heat transfer, fluid flow, and, mass transfer are not treated in a sufficiently fundamental manner and too much of the instruction is given by instructors who are not specialists in these subjects. Historically, the reason for this situation is that the older departments would not generalize the treatment of these subjects so as to provide an adequate background for the process engineer, but this situation is changing and a different pattern is now possible in many institutions. I am particularly interested in this point because many of the engineering science courses necessary for the process engineer should also be available to the students in other curricula such as mechanical engineering, ceramics, and extractive metallurgy. This is a detail of curriculum planning which will have varying importance in different institutions.

A major point which I wish to emphasize particularly to this group is that the usual curriculum in chemical or process engineering comes nearer, in my opinion, to what all engineering curricula should be than any other. Some, such as electrical engineering, emphasize science and analysis to the almost complete exclusion of the cost factors and of the synthesis of science and economics into a design problem. Others, such as industrial or administrative engineering in some institutions, have reduced the science content to such an extent that it is questionable whether the graduates can undertake professional engineering in the sense defined here. The process engineering program in most institutions has struck a happy medium which should set a pattern for the modification and improvement of the other curricula.

An Extension of Graduate Education in Engineering

By L. E. GRINTER
Vice President of the ASEE
Research Professor of Civil Engineering and Mechanics, Illinois Institute of Technology

An interesting development in graduate education in the South is being stimulated by the Board of Control for Southern Regional Education. This Board, acting under the Chairmanship of the Honorable Millard F. Caldwell, Former Governor of Florida with Dr. John E. Ivey, Jr. as Director, is undertaking to assist the Colleges and Universities of thirteen Southern States to integrate their educational activities. The Board of Control for Southern Regional Education was formally organized in 1949 under an interstate compact which has now been fully approved by the legislatures of twelve of the participating states.[1] The Board's stated purpose is to assist "states and institutions and agencies concerned with higher education in their efforts to advance knowledge and to improve the social and economic level of the Southern region." It concentrates, under mandate of the compact, on graduate, professional, and technical education. The wisdom of the objective is very clear since it is obviously impossible for every Southern State to provide education at a high level in every field of professional and scientific specialization. Although a start has been made in only a few fields it is visualized that eventually the regional group of Southern States will be supporting at least one program of the highest quality in each field of specialization extending through the doctorate level. When this is achieved in the several fields of engineering, it will no longer be necessary for southern students to leave the South for advanced graduate work in engineering. In fact, it is reasonable to assume that more students from other sections of the country might well be attracted by the idea of taking graduate work in engineering in the South.

The Board of Control recognizes that financial restrictions upon the extension of facilities for graduate research as well as staff limitations are likely for some time in the future to restrict graduate study in such fields as engineering below the level of the doctorate in many southern states. Hence, an investigation of supplementary facilities that have as yet been little used for educational purposes was decided upon. The first of these explorations was undertaken with regard to the Tennessee Valley Authority, the principal focus being on development and demonstration of *methods* for more effective cooperation among institutions of higher learning and non-school agencies. TVA was selected as a starting point both because of the interest shown by that agency and because of the wide variety of its professional competences and program activities which might have applications for graduate study and research. A committee of educators was appointed by the Board of Control for Southern Regional Education to meet at Knoxville and with the cooperation of the officers of TVA

[1] The thirteenth State—Virginia—also has approved the compact subject to a constitutional amendment; the necessary amendment was introduced at the last session of the Virginia General Assembly. Texas also has participated in activities of the Board; it is expected that a resolution to approve the compact will be introduced at the next session of the Texas legislature.

to inspect TVA research facilities and other program activities in all fields of academic interest. The inspection was carried out during the week of May 15–20, 1950 by the following committee of ten members:

J. Hillis Miller, President of the University of Florida, Chairman
A. J. Brumbaugh, Vice President, American Council on Education
L. E. Grinter, Research Professor of Civil Engineering, Illinois Institute of Technology and Mechanics.
Fred J. Kelly, Specialist for Land-Grant Colleges and Universities, U. S. Office of Education
F. D. Patterson, President, Tuskegee Institute
W. W. Pierson, Dean Graduate School, University of North Carolina
Russell S. Poor, Chairman, University Relations Division, Oak Ridge Institute of Nuclear Studies
Floyd W. Reeves, Professor of Administration, University of Chicago, and former Director of Personnel, TVA
Fred C. Smith, Vice President, University of Tennessee
Frank J. Welch, Dean, College of Agriculture, Mississippi State College

Many TVA officials gave a great deal of time to this project, in particular, George F. Gant, General Manager, and Harry L. Case, Director of Personnel. Staff of the Board of Control worked closely with the Committee in its explorations.

Inspection of TVA

The work of inspection was subdivided by the appointment of three sub-committees. Since each sub-committee produced a rather full report, the present report will be limited in its detailed aspects to the work of Group 1 which conducted the inspection of facilities for research in engineering. This group, acting under the Chairmanship of Dr. Russell Poor of the Institute for Nuclear Studies at Oak Ridge, also was served by Dr. A. J. Brumbaugh of the American Council on Education and the writer. This sub-committee concerned itself with the following TVA divisions: Water Control Planning, Design and Construction; Chemistry and Chemical Engineering; Power Utilization; Power Operations; and Power Engineering and Construction. It is clear that the following academic fields were encompassed: Civil Engineering, Hydraulic Engineering, Electrical Engineering, Chemistry, Chemical Engineering and Agricultural Engineering. On successive days the committee visited Norris Dam and the Hydraulic Laboratory, Wilson Dam and the Divisions of Chemistry and Chemical Engineering, and the Power Division at Chattanooga.

The general plan of inspection which was adopted and which on the whole proved quite satisfactory was as follows:

Conferences were held with the Division heads and with supervisors in the several Divisions for the purpose of (a) securing information as to unique opportunities for research by graduate students either at the master's or doctor's degree level; (b) discovering opportunities that might be open to university faculty members for participation in TVA activities to the mutual benefit of the universities and TVA; (c) identifying personnel in TVA that would be competent, available and willing to supervise wholly or in part dissertations or other research projects of graduate students; (d) finding what educational experiences not strictly research in nature might be available in TVA; (e) determining what financial and administrative problems would be encountered and how these might be met; (f) sensing the general attitude of key administrators toward any cooperative undertaking of the kind under consideration.

Opportunities for Cooperative Research

In very brief summary, the sub-committee saw possibilities for cooperative arrangements between TVA and educational institutions in the following fields of engineering:

(1) Water Control of the River Channel including Hydrology, Hydraulics and Dam Design

Obviously there is a wealth of experience in dam design within TVA. Although of a very practical nature, contact with this engineering office would be a valuable experience for a graduate student, and an opportunity also exists to study accumulated experimental data. The laboratory of hydraulics at Norris is one of the best equipped laboratories in the country. Experimental work comparable to doctorate research is continually under way. A cooperative spirit that would be of great help in starting doctorate research was evident in this laboratory. In hydrology the accumulated data of TVA would furnish excellent material for thesis study.

(2) Chemistry and Chemical Engineering and Fertilizer Research

The TVA chemical laboratories have had an extended program in the study of phosphates in continuous operation. A graduate student would be fitted into this program at any level without great difficulty. The opportunities of combining experience in chemical research with observation of pilot plant investigations in chemical engineering appeared very promising to the committee. A new laboratory building soon to be in operation will further strengthen this section of TVA's activities. The opportunities strictly in chemical engineering appeared excellent at the master's level.

(3) Power Engineering and Power Utilization

TVA has all of the problems experienced by any other electric utility, and the study of these problems leads to possibilities for cooperative research and thesis investigations. In power utilization the main emphasis in research seems to revolve around economics. A great body of economic data have been accumulated over 15 years which could be studied by the methods of statistics, factor analysis and probability. In some of the work a high degree of mathematical competence would be necessary for research at the level of the doctorate.

Administrative Problems

Although the inspection committees found excellent opportunities for cooperative thesis investigations both at the master's and the doctor's level, and although the administrations of TVA and of the Universities appear to desire cooperation, the usual difficulties were encountered in attempting to develop a plan for a working cooperation. The overriding considerations appear as follows:

TVA has clearly defined responsibilities with respect to certain physical developments. These developments of flood control, navigation and power are of great interest to engineering education. Contact with these developments would challenge the imagination of graduate students.

TVA has a policy of cooperative association with surrounding institutions. For example, it does not distribute fertilizer to farmers. Rather it has entered into arrangements for distribution with the land-grant colleges and universities and with farmers cooperatives. It has distributed 22,000,000 seedlings a year, helped develop 33 state, county and municipal parks, but always by working through other institutions and organizations. Hence, TVA has established precedents for cooperative arrangements looking toward regional development.

TVA has pursued the problem of research on the same cooperative basis. In many cases, it has entered into cooperative arrangements with appropriate agencies or into contractual arrangements of a more formal nature. It also has internship arrangements with colleges and universities not only for the purpose of assuring itself a supply of competent personnel, but also to encourage the extension of professional and graduate training in the institutions of the region.

Hence, a basis for cooperation truly exists since, in the words of the General Manager of TVA, "It is of great concern to TVA that its activities and its method of administration be such as to fit into and be a part of the Region." And further, "If additional and improved

methods of relationship with the institutions of higher education can be developed, from a selfish point of view I think these relationships will be of great stimulation to the TVA staff."

The Student and the Professor

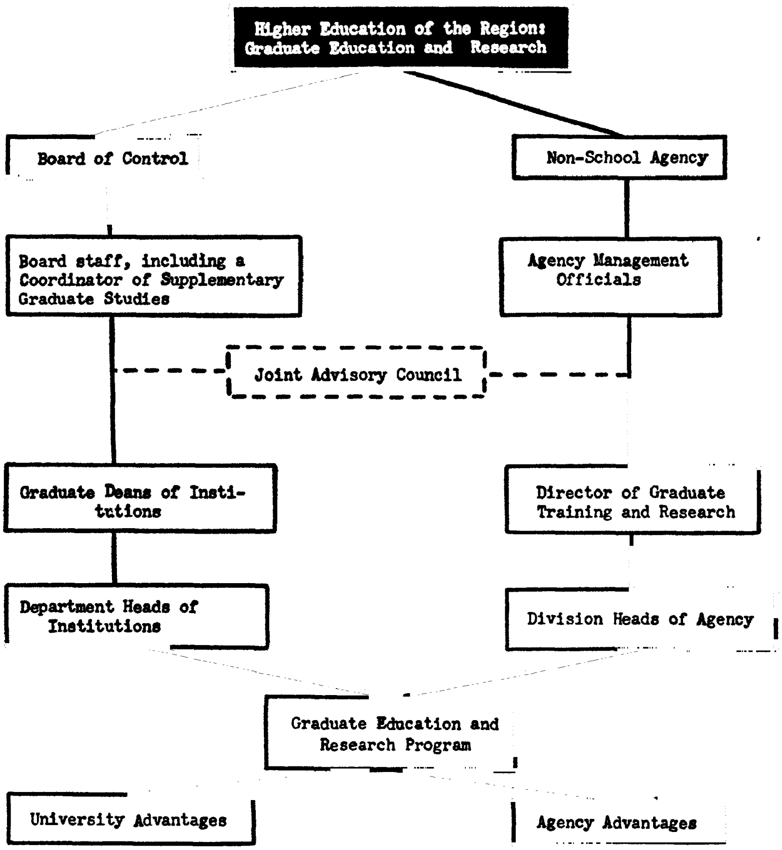
There was much informal discussion of the difficulties inherent in the conduct of a thesis investigation at a great distance from a university campus. It was recognized that, despite the excellence of the TVA staff in many fields, academic direction of certain phases of the thesis research would be necessary. Hence, it seemed agreed that techniques would have to be worked out to interest the professor as well as the student in the possibility of conduct of research within TVA. Such devices as employment of the professor on a consulting basis, the provision of traveling expenses to make it possible for the professor to visit the TVA research laboratory, for the student to make several trips between the two institutions and for the associate thesis director in TVA to visit the campus, were considered to be partial answers to the difficulties discussed. A complete answer to all obstacles lies only in making the cooperative research arrangement desirable not only to the administrative officers of the University and of TVA, but to the professor, the student and the associate thesis director in TVA. If the cooperative arrangement is without value to or is unfavorable to any one of these five parties, cooperation will be spasmodic or nonexistent.

Proposed Administrative Arrangements for Collaboration between Southern Colleges and Universities and "Non-School" Agencies

In presenting an administrative structure to implement programs of graduate education inherent within various non-school agencies in the Southern region—as are partially set forth in Section I above for the Tennessee Valley Authority—the Committee believed that any effective arrangement of university and agency collaboration must be anchored to a few general principles of administration of these relationships. Among the most significant of these principles are the following:

(1) That of institutional * responsibility for award of academic degrees. Included in this principle is acceptance that the institution would approve standards of instruction and programs of study and research. The institution would be responsible for the evaluation of student accomplishments, including the research entering into a dissertation from the point of view of acceptability for satisfying institutional requirements.
(2) That of liberal recognition and acceptance of extra-mural credits obtained under programs approved by institutions and non-school agencies through work in the agency.*
(3) That of institutional approval of agency staff as eligible to guide and direct research. This principle carries with it the policy of recognizing agency staff members as eligible to direct thesis research and the desirability of participation of appropriate agency staff in final examinations of students whose research they have guided.
(4) That of agency approval of institutional staff and of graduate students for work within the agency.
(5) That of mutual agreement between educational institutions and non-school agencies on policy regarding the publication of research findings.
(6) That of providing means for the exchange of information to both institutions and to non-school agencies of research in progress and of other educational opportunities in which both might be concerned.
(7) That of making opportunity for graduate study and research avail-

* The "institution" refers to the university; the "agency" refers to TVA or any other cooperating non-school organization.



1. Faculty stimulation
2. Availability of new facilities
3. Expanded graduate offerings
4. Expanded research opportunities
5. Merging of theory and practice
6. Develops regional understanding

1. Staff stimulation
2. Improved research
3. Use of university facilities
4. Aid from university faculties
5. Help in staff recruitment
6. Expands regional service

able to all groups in the region without regard to race.

The committee regarding the administrative structure represented by the following organizational chart as adequate and workable.

The many and varied details involved in the administration of the programs contemplated in the foregoing sections should be formulated gradually as needed by those officers in the indicated positions of responsibility.

Conclusion

The writer believes that the Board of Control for Southern Regional Education has indicated a direction for greater cooperation between universities throughout the country and government laboratories, regional industrial-research organizations, and industrial laboratories. Such research organizations need to learn more of their responsibilities for the production of scientific personnel. And once the Uni-

versity has drawn the cooperation of such non-school agencies it must relax sufficiently to make it possible for the advantages of joint training of graduate students to become a practical possibility. It is the writer's understanding that such cooperation is not as unusual in Europe as in America.

In final reference to TVA it is, of course, self-evident that TVA is a national institution, and, as such, any arrangement provided for students from southern states would be open to students from other sections of the country. It is also evident that TVA is only one of a long list of non-school agencies in which research is either the primary objective or at least a very important objective.

College Notes

Two new buildings were put into use on the campus of **Missouri School of Mines and Metallurgy** of the **University of Missouri** at Rolla, Missouri, with the opening of the fall semester on September 11. One is the new Mechanical Engineering Building just completed at a cost of $500,000.00, and which will house the Mechanical Engineering Laboratories. The other is the new dormitory, erected at a cost of $600,000.00.

Paul Harteck, head of the University of Hamburg and one of Germany's foremost authorities on hydrogen isotopes, is to join the staff of **Rensselaer Polytechnic Institue** on January 1 as visiting research professor of physical chemistry. Dr. Harteck's most recent work has been in isolating quantities of tritium, the probable central material in the projected hydrogen bomb.

Guido Ferrara, assistant professor of electrical engineering at the **University of Detroit,** has been named acting Director of the Department of Electrical Engineering.

Pietro Belluschi of Portland, Oregon, who has gained recognition as one of this country's foremost architects, has been appointed dean of the School of Architecture and Planning at the **Massachusetts Institute of Technology.** The Institute's new dean will succeed William Wurster, who held the position from 1944 until May, 1950, when he returned to California to assume the post of dean of the School of Architecture of the **University of California.**

A distinctive "engineering project plan" which places a premium on student ingenuity and initiative has been placed in operation on a college-wide basis in the College of Engineering at **Cornell University.** The program requires each student to complete an individual problem of specific research as part of his final year's work in the five-year undergraduate curriculum. Projects are assigned to single students or to teams of two or more. Although instructors are available for consultation, it is left to the students to use their scientific imagination and technical ingenuity in finding a solution, Dean Hollister explained. A primary purpose of the work is to provide the young engineer with experience in research procedures in preparation for development problems which commonly arise in professional work after graduation.

The Social Impact of Technological Change

By YALE BROZEN

Professor of Economics, Northwestern University

The first Industrial Revolution—during which men learned to use metals and harness animals and in which they invented the plough, the wheeled cart, and the sailing ship—preceded 3000 B.C. Although it produced Babylonian, Egyptian, and Greek civilization, its benefits were confined to a few people in each of those states. Most of the increased product made possible by technological advance was funneled to the support of a ruling class. This class contributed much to the technique of administration, to literature, art, astronomy, mathematics, and philosophy, but it contributed little to the further advance of technology, since its members had no regular contact with the effort of production. The class divisions which resulted from the first Industrial Revolution ended the Revolution.

The second Industrial Revolution began its most explosive phase after 1660 in Western Europe. It terminated about 1918. (After that date, the rate of growth of technology began to decline, according to Lewis Mumford and S. Lilley.) Its benefits, in contrast to the first Industrial Revolution, have spread to almost all the inhabitants of its primary locale, Europe and North America.

Political Consequences of Change

The benefits of technological advance included not only rising material standards and improving health and longevity, but also the increase in human dignity resulting from the displacement of human muscle by inanimate sources of energy. The decline in slavery and the rise of mass democracy were a part of the same movement.

At present, the political consequences of the shifting balance of power resulting from developments in the area of military weapons—particularly the atom and hydrogen bombs—occupy newspaper headlines and the minds of men. Somewhat less obvious is the fact that technological advance in the production of subsistence goods may do as much to shift the balance of power as advances in the powers of destruction. Through a reduction in that portion of a nation's resources which must be devoted to the maintenance of living standards, resources can be released for the development, production, and use of weapons. If Chinese, Indian, or Russian productivity could be raised to a level comparable with that of the United States while living standards remained unchanged, the release of resources for war effort would make them far more formidable enemies than would the mere possession of the knowledge necessary for building an hydrogen bomb.

In the past, we have seen the center of world power shift from Spain to Great Britain and then to the United States because of more rapid technological advance in the rising nations. Whether world power will shift to Russia or to India or China is a question now troubling those who must make decisions on political and military alignments.

More than technical knowledge is required for economic progress and growth in military potential. Knowledge of technological possibilities can be fruitfully applied only by the investment of large amounts of capital. Even if no equipment were required to make use of better techniques, capital would have to be in-

vested in research and education. Acquiring and spreading the "know-how" necessary for improvement in productivity requires the diversion of men from current production and, therefore, requires capital for their support. The cost of sending British industry teams to study methods in the U. S., which was partly financed by ECA, is an example of the capital required for the task of spreading knowledge.

Thus the backwardness of a region may result from a lack of capital rather than from a lack of technical "know-how." England does not lack the knowledge of technological possibilities or even the technological leadership required for improvement of her average technology. Her great problem is her lack of capital. Her social mores, industrial and economic organization, and tax structure have caused a dearth of this factor. As a consequence, the English government faces the problem of increasing the capital supply in order to raise the technological level. More capital and improved technology will be obtained only if English standards of living are reduced, unless capital can be obtained abroad.

Because of the intimate connection of capital supply with technology, there has been a tendency to confuse the lack of capital in backward areas with the technological ignorance of those areas. Point IV is aimed toward the export of "know-how" to such areas as a method of improving their productivity. But until the economic, social, and governmental structures of those areas are changed to promote the growth and productive use of capital, their technologies will continue to lag.

The United States today, as well as backward areas, is confronted with this problem. Our technological advance is directly hinged to the capital supply no less than that of the rest of the world. If we follow policies which reduce the rate of saving or inhibit its flow into capital markets, enterprises will be unable to obtain a large supply of this resource. The resulting reduction in the supply of capital will carry down with it the rate of technological advance. The international implications of this reduction in a world in which we are engaged in a race for power are obvious.

Technological development has depended not only on the supply of capital,

TABLE 1*

World Production of Mechanical Energy, 1935.

Expressed as Thousands of Tons of Bituminous Coal

	Total Power		Total Power
The world	1,649,266	Germany	207,085
North America	659,619	Italy	11,126
South America	45,834	Poland	29,515
Europe (exc. of U.S.S.R.)	632,112	Rumania	14,113
U.S.S.R.	141,568	Spain	9,658
Asia (exc. of U.S.S.R.)	127,246	Yugoslavia	2,461
Africa	15,123		
Oceania	26,764	China	26,755
Selected countries:		India	25,136
United States	621,696	Japan (proper)	48,863
British Isles	226,655	Australia	11,908
Czechoslovakia	17,247	Union of South Africa	13,587
France	54,430	Manchukuo	11,828

* A. P. Usher, "The Steam and Steel Complex and International Relations," *Technology and International Relations* (ed. by W. F. Ogburn, Chicago, 1949), p. 66.

TABLE 2†

WORLD RESOURCES OF MECHANICAL ENERGY

Expressed as Millions of Tons of Bituminous Coal

	Total		Total
The world	8,670,285.8	Germany	308,170.5
North America	3,087,143.6	Italy	11,320.4
South America	166,881.0	Poland	97,380.5
Europe (exc. of U.S.S.R.)	789,548.8	Rumania	6,142.5
U.S.S.R.	1,313,685.3	Spain	17,220.0
Asia (exc. of U.S.S.R.)	2,347,544.1	Yugoslavia	11,359.0
Africa	765,005.3		
Oceania	190,477.7	China	2,158,840.0
Selected countries:		India	99,754.6
United States	2,513,693.4	Japan (proper)	41,658.2
British Isles	177,047.5	Australia	141,158.0
Czechoslovakia	32,932.1	Union of South Africa	210,370.0
France	33,472.0	Manchukuo	4,804.0

† *Ibid.*, p. 69.

but also on energy resources. The displacement of human muscle as a source of energy was possible because of the availability of wind and water power, before the steam engine, and the availability of fuel since. An index of advance can be drawn almost as readily from data on the amount of energy used as from data on the quantity of capital or from direct measurement.

Using the data of 1935, the four largest users of mechanical energy were the United States, the British Isles, Germany, and the U.S.S.R. in that order. The fall of France early in World War II might have been predicted from the fact that its energy use, and, therefore, its national power, was only about one-fourth that of Germany.

If technological advance continues to depend on energy resources, aside from capital requirements, then relative potentials for different nations may be measured in terms of their coal, oil, and water-power reserves. Those of North America are more than double those of the U.S.S.R., but they are little more than those of Asia exclusive of the U.S.S.R. Europe (exclusive of the U.S.S.R.) and Africa each have potential energy resources equal to about one-fourth those of North America.

In terms of the present direction of evolution of technology, Asia (particularly China, which has over nine-tenths of Asia's energy reserves) and North America have the greatest potentialities for progress as far as energy resources are concerned. In terms of potential population growth, Asia is more likely to become the dominant world power than either the U.S.S.R. or North America. Only if we succeed in maintaining a rate of capital growth sufficient to offset the energy and population potentials of Asia can we maintain our dominant position in world affairs.

Russia's great emphasis on atomic energy development is the logical result of the deficiency of her energy reserves relative to those of North America. If atomic and solar energy become economic sources of power, the world's energy and political balance may be changed.

Technology and Population

Technology has produced changes in the pattern of individual lives through its impact on the goods available for consumption, on the size of the family and its function and outlook, on the occupations

followed by men, and on the security of states. In addition, it has produced vast changes in population. The 1600 million increase in world population in the last 250 years is nearly three times as great as the 600 million increase of the preceding 10,000 years, a period 40 times as long. The annual rate of increase rose from 0.64 persons per 1000 to 5.5 per 1000.

Populations not accustomed to living with modern technology typically have high birth and high death rates. If, in addition, population density is high, the introduction of advanced technology in backward areas simply contributes to further increase in population density with little effect on living standards. Only where initial population densities are low (if birth and death rates are high), or where population increase is exported, does the introduction of modern technology lift standards.

Social change lags behind economic development. Where population densities are low, a rise in income resulting from technological advance can be maintained as a rise in per capita income for fairly long periods despite high birth rates and declining death rates. If maintained long enough (about a century) changes in attitudes determining marriage age and family size can take hold before population rise sends per capita income back to low levels. Technological advance, in that case, produces a permanent increase in standards.

Unfortunately, many of the backward areas in the world today have high population densities and potentialities for explosive population increase. Egypt, India, China, Korea, Formosa, and the Caribbean islands find improved productivity a source only of more mouths to feed. Increased production brings the usual drop in death rate and rise in population. Fertility, however, does not drop enough to make permanent the movement away from the Malthusian limit.

One of the reasons for the drop in birth rate with technological advance, when this occurs, is the urbanization of population which seems to be inevitably associated with advance. As productivity on farms rises, it becomes possible for an increasing proportion of the population to live in cities. Not only does it become possible, but the movement occurs. The directions of technological advance have been such that the assembly of materials dictated by technical requirements and the cost pattern dictated by the available forms of transport make economic the location of major portions of production at certain restricted sites. The resulting urbanization of the population creates circumstances in which children have little value to the family, since there is little room for a garden plot or other forms of productive endeavor for them, and have great cost, since food and other necessities must be transported to the city. These economic pressures together with urban attitudes springing from other sources combine in enforcing a low birth rate.

The Effect of Change on the Social Structure and the Family

Our present value system is anti-totalitarian. A continuation of technological change in the direction of a more rapid growth in the efficiency of highly centralized, large organizations than in that of small and decentralized organizations may change this. Past movements have been antithetical to democratic values. The steam engine, which is much more efficient for large scale power production than for small, gave great impetus to the growth of large industrial enterprises. Transportation and communication, which once made the marketing of the produce of large scale enterprise expensive, have been continuously improved with the consequent reduction of this barrier to centralization.

Once the scale of enterprise was enlarged, research and development began which reinforced the trend. Small enterprises tended not to support individual research programs since saving of cost on a few units of product did not justify the expense. Large enterprises, in which a

small saving in cost on individual items meant very large total savings, found it economic to support programs directed toward the solution of the problems peculiar to their scale of operation as well as those common to all scales. As a result, technological change produced in their laboratories furthered the growth of efficiency of large scale enterprise relative to small enterprise.

From the social point of view, research which solves the problems of small enterprises may be as economic, or more, as that which solves the problems peculiar to large scale production. The total saving in cost or gain in value of product will be as large when small savings or gains per unit occur for the total product produced by *many* small enterprises as when it occurs for the total product of *one* large enterprise.

We must prevent our society from becoming an aggregate of a *few* large organizations if we wish to preserve our democracy and our freedom. The rise of Hitler in Germany was preceded and conditioned by the rationalization and cartelization of German industry and labor. Reorganization of research in the direction of aiding small enterprises is essential to the preservation of traditional American values.

Beginnings have already been made in providing research and development centers whose services are available to small enterprise. The Mellon Institute of Industrial Research, Battelle Memorial Institute, Armour Research Foundation, and Midwest Research Foundation are examples. By the use of these centers and by the use of research centers supported by the cooperative effort of many firms, such as those organized by the baking, the laundry, and the gas industries, research which is uneconomical for one small firm, but is worthwhile for several, may be undertaken. Specialized engineering firms also serve this purpose. Governmentally supported research centers could similarly devote themselves to such problems, as the Department of Agriculture now does.

Past inventions and improvements have not uniformly contributed to the decline of small scale production. The gasoline engine and electric motor have done much to preserve the family size farm and the small shop and to keep some production in the home.

Up to recent times, production was progressively moving out of the home and into the factory. Spinning and weaving were among the early casualties. Home canning, baking, clothes-making, laundry, and entertainment are among the more recent. The result was a deterioration of the economic basis of family life with the consequent decline in the birth rate and rise in instability in family relations. The family began shifting to an emotional base for its continued existence with a consequent growth in the role of romantic love. Whether this is an improvement is hotly disputed by those holding different value conceptions.

Recent inventions, such as the electric motor, the home laundry, the sewing machine, the deep-freeze, and television, are moving production back to the home and the family. Television alone has changed family living habits by leading husbands, wives, and children to spend 40 per cent more of their leisure time at home. Whether the total impact of these inventions will be sufficient to raise the value and reduce the cost of extra children to the point where the birth rate is affected remains to be seen. Whether the increased economic role of the family unit will reduce the divorce rate cannot be foretold. We may postulate, however, that a continuation of change in this direction certainly will not hinder movement along these lines.

The Effect of Change on the Likelihood of Continued Progress

Technological change which brings giantism not only imperils democratic values; it also signs its own death warrant. Social structures which are rigid and in which men are not free inhibit progress. Change finds it much harder to get itself accepted in large organizations since more

decisions are made by rule and less by re-valuation of possibilities. A large organization is operable only when a large part of its tasks can be put into a repetitive, unchanging form.

Not only is change less likely to be accepted in a giant organization; it is less likely to be accepted in a society composed of such giants. If there is only one decision-maker in an industry, a "no" from that one is the end of any attempt to introduce a new idea. The cracking process, for example, was turned down by the Board of Directors of the old Standard Oil Company. Had Standard Oil not been broken into several separate companies by an anti-trust decree, Dr. William Burton might not have found a new decision-maker to whom he could sell the idea. Similarly, the National Biscuit Company failed to use the band oven that was developed in its shop. Only after competitors began using it did National Biscuit take it on.

Technological change which tends to increase the scale of enterprise decreases the opportunity and likelihood of further change. If a nation is to maintain its avenues of expansion, it must develop the techniques appropriate to small scale production.

Has Change Been Good or Bad?

Because of its effect on population density, family life, personal relationships, and value orientations, the value of technological change has been questioned. J. S. Mill argued that "It is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being. They have enabled a greater population to live the same life of drudgery and imprisonment, and an increased number of manufacturers and others to make fortunes. But they have not yet begun to effect the great changes in human destiny which it is in their nature and in their futurity to accomplish." At this point, a century later, the hopeful aspect of Mill's statement may seem closer to realization, yet we still see explosive population increases occurring in many places where technology is improved with the Malthusian consequences Mill dreaded.

There were values inherent in pre-industrial techniques of production which may have been unwarrantedly sacrificed. Gandhi argued for the retention of cottage industry to prevent the domination of life by the soulless rhythm of the factory and by unnecessarily created desires. His argument was convincing enough to lead the Province of Madras, India, to prohibit the expansion of textile mills.

Perhaps the heedless rush to methods which gave more product unnecessarily sacrificed values which could have been preserved. Perhaps we could have both had our cake and eaten it. In the case of India, some observers believe that reconstruction of capital markets, of distribution, and of technical education would make cottage industry economic. With the present situation, mill production is more economic for reasons which lie outside the choice between methods of production. If the services of a skilled marketing organization, skilled inspectors and supervisors, and a skilled purchasing agent were provided to cottagers, home production would become economic and the values of the old way of life would be preserved.

It may be argued that the depersonalization of his work and the loss of control over his work-setting has made modern man a ripe subject for the psychiatrist's couch. The performance of a small task, whose useful end is not apparent, under circumstances which may be arbitrarily changed because of what seems to be the whim of remote beings, may create a loss of any sense of an orderly, rational universe. Perhaps our society is sick, in the sense that it creates a high incidence of psychosomatic illness, because of the development of modern technology.

On the other hand, modern man is far more objective than his ancestors were. The outlook of the scientist and the engineer has percolated into many corners of the world. Authoritarianism is on the de-

fensive because men have learned to test the truth of a statement by examining the circumstances and experimenting where necessary. Only by learning to truly understand nature could man obtain dominion over her. The requirements for advancing technology discredited authority as a source of truth and gave man an attitude which, by extension into questions of social policy, may enable him to become master of his social environment. He may thus become able to devise the means for preventing the social eruption which would lead to his annihilation.

Sections and Branches

The **National Capital Area Section** of ASEE (covering Maryland and the District of Columbia) held the first meeting of its 1950–51 school year on Tuesday evening, October 3rd, in the Auditorium of the Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland.

Russell B. Allen, Head, Civil Engineering Department, University of Maryland, Chairman of the Section, presented as guest speaker Dr. Thomas E. Hibben, Advisor for Foreign Economic Development, U. S. Department of Commerce, who adressed the section on "Point Four and Its Implications for Scientific and Engineering Education." Other program participants included Henry H. Armsby, Associate Chief for Engineering Education, U. S. Office of Education, and Vice-President of the Society, who brought greetings from the Executive Committee, and spoke briefly on "Federal Plans for Emergency Training Programs," and S. S. Steinberg, Dean of Engineering, University of Maryland, who reported on the Seattle Meeting of the Society.

The next regular meeting of the Section will be held on February 6, 1951 with George Washington University serving as host institution.

The Role of the Engineer in International Affairs*

By PAUL B. McKEE

President, Pacific Power & Light Company

Whatever the role of the engineer is or may be in national or international affairs, you share a great responsibility for his effectiveness. Perhaps it goes without saying that you have more influence than you realize on the character and thus on the careers and the future of the young men who look to you for training and inspiration.

It seems wise to create some limiting specifications within the broad subject assigned to me in order that we may come down to a practical and, I hope, interesting discussion of the subject with emphasis on the opportunity for the young men who are now preparing to play their part in the scheme of things. In the first place, I have assumed that we are to speak of American engineers in foreign service because it is the American engineer for whom all of us have the primary responsibility. Second, I have assumed that the world will continue at peace and that it is not the purpose of this discussion to consider the engineer in war, although no one will be more important if we come to the point where the fatal decision has been made to blow up one another and the world with atom bombs and other horrific instrumentalities.

A description of the achievements of the engineer of World War II, in the actual military operations in the great construction and manufacturing projects required to back up our field forces and in the procurement of strategic and essential materials both at home and abroad would require the writing of many volumes. Let us pray that while preparing for this eventuality our engineering talents will not be needed in this field.

On the contrary let us assume that the role of the engineer is to look and work for better standards of living and better human relationships and more and better things for more people throughout the world.

Further, I have assumed that any engineer trained in our great schools will expect to practice his profession in the atmosphere and against the background of our democratic and free-enterprise system where the efforts of the individual are to be rewarded in proper proportion to the energy and ability with which he conducts himself. Further. I have assumed that within these specifications you would like to have my idea of the kind of training and experience and general attitude which will make our young men of the greatest value in foreign service and enable them to achieve the best results for their employer, for themselves and for their country.

International Relations In Transition

There has been an astonishingly wide change in the outlook of the American people, with respect to our relations to foreign countries. The first World War and the depression succeeding and then the second World War have brought us forcibly to the realization of intimate and inescapable international relations. Any one who would have said 40, 25 or even 15 years ago that this country should in 1950 be spending billions annually in strengthening and supporting other coun-

* Presented at the General Session of the ASEE Annual Meeting, Seattle, Washington, June 21, 1950.

tries and peoples, would have been considered insane. There has thus been an awakening of the necessity of these close ties with the world at large. It has been realized that the ties to foreign lands are so close and so essential that reasonable wellbeing and safety for our country depend in increasing measure on the existence of corresponding conditions in the outside world.

This increasing intimacy of relation is in part the result of the rapid and general intercommunication and the great speed of transportation—as compared with conditions a very few decades ago. The expanding scope of the press and of the radio and the increasing utilization of air transport have been important elements in bringing various parts of the world together, in emphasizing to our citizens the element of foreign policy and of acquainting them with the working groups of the Government that have to do with formulation and execution of policy. Subgroups of Federal departments are stationed in Germany, Japan and many other countries.

Hence, there is more and more a call for men to represent the United States in foreign countries, in operations pertaining to politics, administration, business, engineering and construction. These men represent the Government itself, and commercial, engineering and construction interests. Hence, comes a special call and opportunity for young engineers to take up foreign service.

Work in other lands, with their broad background of history and culture, is attractive to certain men and women, in part because of the novelty and the variety and keenness of interest attached to it, and in part because of the broader opportunities and greater monetary returns. Until within a relatively short time, England and Germany sent out more of its young and vigorous men to foreign countries, but recently the United States, with its increasing participation in world affairs, is carrying out many operations and enterprises abroad.

Preparation for Engineering Abroad

How should we prepare these young men for work abroad? It seems to me we should recognize, in the first place, that mathematics and engineering and the various formulae under which we engineers proceed practically are the same the world over. Therefore, if one is to practice engineering abroad, he should first of all be given the finest and highest type of engineering education available.

It is seldom that a young man at the beginning of, or during, his undergraduate college career plans definitely for service abroad. Usually, at that stage he is simply training himself to do engineering work wherever it may be found. In my opinion this is a distinct advantage. In other words, from an educational standpoint the best possible basic training for work abroad is a sound and thorough knowledge of reading, writing and mathematics, plus a thorough groundwork in basic engineering principles. A good working knowledge of the English language and of the history of our country and at least a general understanding of the history of the world is also essential.

If during high school or college this candidate for future foreign adventure is fortunate enough to be stimulated into a real study of an ancient language such as Latin, it will serve him in great stead when it comes his turn to learn the language of another land. This is borne out by my own experience when it became necessary for me to learn Portuguese from scratch, as it were, at the age of 35. Without the foundation which comes to one through the study of an ancient language I would have been even more handicapped than I found myself to be. If the engineer going abroad knows the specific country in which he is to work, it is obvious he should have as much training in the particular language as is possible to get here at home. Certainly, at least a working knowledge of the grammar would be tremendously helpful. Any modern language in addition to English whether it be Spanish, Portuguese, French

or German, will be a great advantage, but it seems to me that Latin is essential

In our own company it was our practice in Brazil to try to put the new and younger American engineers at work in the interior away from the large cities where there was little English spoken and where they had to speak the language in order to eat In this way some of the more adaptable young men were able to gain a working knowledge of Portuguese in a comparatively short time Once we outdid ourselves by sending a very promising young engineer into the interior where he took up his abode with a very fine family of "fazendeiros" (plantation owners) There he met a charming senhorita who could speak nary a word of English and they were married before he could speak a word of Portuguese

When should the young engineer go abroad—immediately after leaving college or after some years of experience in some phase of his profession at home? My own experience indicates that a few years of practical work at home and a degree of seasoning is better We are building so many plants and spending capital money in such large magnitude and operating so many facilities in this country as compared to the volume of similar undertakings in other countries, that a man can gain experience here faster than he can anywhere outside of the United States All of us know out of our own past that the place to get experience is where the work is going on Therefore, I recommend that the young engineer planning for work abroad serve his apprenticeship at home

Given a good practical, general and engineering education and a few years of experience at home, a workable understanding of history, a person should be ready for his adventure abroad provided, first, that he is interested in going abroad, second, and perhaps more important, that his family is interested in going abroad and that he and they have a human outlook and lack of prejudice which make them able and willing to work with people It should be remembered that the folks with whom they come in contact will not always appear to be the kind of people whom our candidate and his family may have met on Broadway or Main Street or with whom they may have gone to school and college Experience will show that way down deep human nature is pretty much the same the world over, but environment and custom change the outward appearance and point of view of the individuals Unless the candidate's family background and character and education make for a desire to understand and get along with people, then the family had better stay at home

Personal Adjustments are Important

There are many fields of international service where physical comforts are at least the equivalent of those found in our own home town, on the other hand if one is to fulfill his destiny as a real adventurer into foreign service, he must be prepared for some physical discomforts and must develop within himself the resourcefulness and contentment of mind and spirit to adjust himself to new and sometimes less comfortable situations

Again at this point let us not overlook the fact that if this particular candidate for fame happens to be a married man with a family, they too must be prepared for an adjustment of this kind I am sure than anyone engaged in engineering work outside of this country or supervising their work in the foreign field will agree with me that while the characteristics of the man are important, the ability on the part of his wife to get along under new and strange conditions in a foreign land is even more important

While what I am about to say is obvious, I believe it is worth the emphasis which comes from repetition to say that all of us have seen good men in our own country held back by unfortunate family situations and mediocre men helped to succeed by the right kind of family relationships And, while this is true at home, it is vital abroad

Again, drawing on my own experience,

after several mistakes in the business of bringing men to foreign service without having a chance to give his wife and family an opportunity to know what they would be up against and without the chance to meet the family in the United States before they went abroad, we made an absolute rule that no one could be employed or taken from available candidates in the United States until some senior member of the company, with ample foreign experience, had a chance to discuss the situation thoroughly with all members of the family. When you remember that it requires a substantial sum measured in the thousands of dollars to move a family from home to a location abroad and when you realize that one mistake costs great expense and delay, I am sure the need for this precaution will become apparent.

I believe that we of the United States are not yet sufficiently conscious of the simple points which I have just made, and that a nationwide program should be developed under which men and women with successful experience abroad could be available as counselors both to potential employers of younger people and to candidates for service beyond our boundaries. I submit that this would be a most worth while function and, if done on a sufficiently broad scale and by people of outstanding ability, great benefit to all should be gained thereby.

Let us now assume that we have our candidate well educated and well grounded in the first few years of his practical engineering experience. Let us further assume that an opportunity comes to him to go abroad. What will he need to do? And what will he be up against?

Probably the first thing some well-intentioned adviser will tell him is, "When in Rome, do as the Romans do." My own experience indicates that this is the kind of advice which comes from lack of understanding and experience on the part of the adviser. When my opportunity came to go abroad, a wise old counselor said to me, in talking about the matter of behavior in another person's land, urged me, above all, to read again Polonius' advice to Laertes, which you will remember is as follows: "to thine own self to true, and it must follow, as the night the day, thou canst not then be false to any man." Then he added, above all just be yourself.

We in the United States have developed a fine habit of life and a high level of business and engineering integrity which will command respect abroad if permitted to become evident in an intelligent manner. I certainly would advise any young man who is going beyond our borders to remember the best things of our civilization, take them with him simply and with humility, and not to try to dress himself up in a lot of strange and unfamiliar customs and mannerisms which will be of no benefit to him and will merely tend to make his friends abroad think that he is a bit queer.

Human nature is the same the world over. Respect for integrity, proper behavior, and decent humility is of value no matter where you may be. It is quite true that customs vary. In South America, for instance, one cannot always proceed with the briskness and determination to get quickly to the point as may be done here at home. Naturally, there are many other modifications to one's normal way of life at home too numerous to give in detail here, but which quickly become apparent to the person of adaptability. Nevertheless, the fundamentals are the same, and I am certain that the best advice that can be given to a young man about to go abroad is just to be his natural, decent, American self.

Learn the Language and Customs

As I have mentioned before, it is my opinion that the next most important move is for the young man to begin a diligent and careful study of the language of the country in which he is to work. Every spare moment should be devoted to this job and he should make it apparent to his new associates that he is doing his level best to learn their language. They will not expect him to be proficient overnight,

but they will expect him to try his best to master their language.

In my opinion the next in importance is for the individual to begin and carry through a careful study of the history and the fundamental laws and customs of the country in which he is to work. Also, he should make an earnest effort to learn and understand the geographic and climatic conditions and resources of the area. Information about all of the physical and philosophical characteristics are available in the literature and through conversations with people he will come to know. Everyone the world over likes to talk about the land of his birth and there is a veritable ocean of data of this kind ready for the person who evidences a proper interest. I am sure that in most cases this sort of study will bring out the good points—and every land has many of them—and will set up the danger signals.

In all of this there are a few legitimate tricks which will be learned quickly by the discerning individual. For instance no one in the world likes to be called a "native." There is a connotation to that word which is bad and the use of it should be avoided like the plague. Neither does the other person like to be told that his way of doing things is not good because "it is different from the way we do it in the States." He should try to find the good things which people are doing and emphasize them, at the same time recognizing the weaknesses, and as he would do at home try his level best to offset them and overcome them.

Unwarranted interest in the politics of the other fellow's country will constitute a bad blunder. When we go abroad as guests of another land, it is not our function to tell them how to run their government. That is their business. To do otherwise is a violation of a principle which was enunciated by a famous engineer about the time I was starting my own career. His "principle" was simple, but I am sure you will all agree it was thoroughly sound. "Never delegate authority without an equal percentage of responsibility, and never accept responsibility without corresponding authority." If one interferes in politics of another land, he is attempting the exercise of authority without being confronted by the corresponding responsibility of citizenship.

Difficulties Often Encountered

Now as to physical operations: In most cases the engineer abroad is much more on his own than he would be in our great land which is full of railroads, telephones, highways, factories, and all the other facilities which make for speed and ease in the carrying on of engineering and construction work. For instance, if he forgets to order a particular piece of machinery essential to his plant's operation, he can usually get it from the factory by airplane or otherwise in a matter of a few hours. On the other hand, most countries abroad are not so adequately equipped with transportation, communication, and manufacturing facilities and therefore engineering and construction require very careful planning ahead. Failure to do so may result in costly and unfortunate delays. He will also need to understand all of the possible delays which will result if he fails to familiarize himself with the rules and regulations in the customs house, in building codes, and in other similar restrictions. We are all confronted with corresponding regulations at home, but they raise much greater mental barriers abroad if we fail to familiarize ourselves with them.

If he is to carry on his work profitably, economically, and expeditiously, he will need to understand how to use the materials and the personnel resident in the country of his adoption. This will require patience and the example of hard work. It is essential that the dignity of the human being in whatever field from laborer to capitalist be kept constantly in his mind, and he must remember always that he is the stranger and not the people with whom he is working.

Engineers are Ambassadors of Good Will

I am sure that all engineers and engineering executives whether in this country or elsewhere, must think of themselves as practical teachers and educators. If we are to get the right kind of assistants to carry on any sort of enterprise, we must spend a good part of our time educating and stimulating the men and women who will work with us. To the engineer who is to work abroad, the development of this ability and characteristic is even more important than it is at home. He must make his new friends feel that he will do anything he can to bring to them the knowledge and experience which he has gained in this great United States of ours, in return for which they will help him to gain an understanding of the conditions under which they live and work and of their language. Happy will be the man working abroad who finds within himself the abilities and energies to do this very interesting and worthwhile educational job. It will be helpful to him and it will also be of great value to our country. While we have diplomats and specialists abroad who are charged with the responsibility of seeing to it that our point of view and way of life are properly presented; nevertheless, each one of these young engineers who go abroad can be invaluable as ambassadors of good will.

How wonderful it is that an American going abroad has the right to carry with him the conviction that he springs from a country which in the comparatively few years of its existence has done more to develop the rights and freedom of the individual than any other nation in the history of the world. That he may carry with him the realization that his own country has set a standard of development and technical performance which is unequaled.

Naturally, those of us who stay at home must do our utmost to preserve our own way of life in his absence, but on the other hand he can be of great help by bringing to other countries, ideas which will gradually make it possible for them to approach our high level of accomplishment. In this effort the engineers will play a prominent part, as they have in our own country's development. Naturally, the engineer cannot be expected to do it alone—he must have the help of the medical profession, the legal profession, statesmen, diplomats, businessmen, and in fact our entire citizenry.

You, I am sure, have come to the conclusion that the United States must assume its proper position of leadership and cannot forever exist as an oasis of prosperity in a desert of misfortune. It is my belief that we must work at this job in a practical manner and I repeat for emphasis that the engineer will have a great part in helping to win the game against the forces which are trying to take our position of leadership from us. We have demonstrated at home that our system will bring the greatest good to the greatest number. If we can help do a similar job abroad we are safe.

Gentlemen, you who have so successfully trained the present generation of engineers and who now have before you the great opportunity and the great responsibility for training the men of the future upon whom we must rely for our success at home and abroad—I salute you!

A New Approach to the Doctor's Degree for Engineers*

By D. H. PLETTA

Chairman, Department of Applied Mechanics, Virginia Polytechnic Institute

Individual members of this Society have for many years endeavored to change the engineering curriculum. Some of the suggestions made decided improvements; others were perhaps questionable; all were no doubt sincere. The clamor for change has increased recently, due in part to the desires of some to include more of the humanities, and of the realization of others that a broader foundation in basic science coupled with more training on a graduate level was an inescapable necessity.

The approach suggested in this paper encompasses both of these aims to a greater extent than do present curricula, but would necessitate considerable change in these before adoption could be effected Briefly the proposal is this: stop the patchwork bolstering of the curriculum and integrate the overall educational requirements for true professional stature, as the other professions have done. The plan would include a four year course in the humanities, basic engineering science, and personnel management, terminating with a B.S. Degree. This should be followed by two more years of specialization in one of the engineering branches on a high graduate level for those who have the ability, and culminate in a one year internship, a Doctor of Engineering Degree and professional registration (see Fig. 1).

Novel Features

This proposal breaks with the past, for it reverses the trend toward specialization too early in the engineering course, which has resulted in the fragmentation of our profession, certainly with questionable effects. But before describing this 4–2 plan in more detail, it might be well to discuss the reasons prompting such a change.

Doctoral candidates in engineering today complete the *equivalent* of nine academic years of work for a Ph.D. as compared to *seven* for a Ph.D. in Arts. This extra work may be accounted for by comparing the 225 quarter credits required for a B.S. in engineering with the 180 quarter credits required for a B.S. in the arts, and by adding another year for language requirements which the engineer must make up, but which is included in the arts students B.S. curriculum. I see no way of reducing this total of nine equivalent years of work except by deleting some professional work or the language requirements. Neither is desirable but some reduction seems to be in order.

The engineering profession has long known that graduates of its four year courses were not ready to practice on a full professional status upon graduation. Industries have sought to implement this deficiency by training courses and restricted internships of varying length. Colleges have likewise established additional training on a graduate level, and have continually added to the curriculum, channeling this course content into ever narrowing specialties. State licensing agencies in increasing numbers, are requiring a period of acceptable experience after college for full professional recognition. Where has this haphazard growth led the profession?

* Presented at the April 1950 meeting of the Southeastern Section, ASEE at V. P. I.

We might begin by comparing our profession with those of law and medicine. Table I lists certain significant deficiencies in engineering. Although engineering has been taught in the United States on a collegiate level for 122 years, as compared with about 180 years for law and medicine, we have lagged behind these professions in establishing licensing laws, conceiving an integrated professional training program, founding a national professional society, accrediting curricula and establishing a National Board of Examiners. The most glaring comparison is our reticence to become licensed; only 42% of those now practicing are legally qualified compared with practically 100% in law and medicine.

This reticence is, in no small way, due to early specialization with its attendant lack of esprit de corps. Although we did not fight each other, we certainly did not begin helping each other until recently. Only 15% of us are active in coordinating our common professional interests, and few indeed protested the labor bill in the last Congress which would have subjected us to CIO or AFofL unionization. Engineers have rendered truly astounding technical service to the public, but if you believe we have achieved comparable recognition with the other professions in the mind of the public, you should read "Public Relations Interpreted as Good Engineering" by Harry W. Lundin in the February, 1949 *American Engineer.* The public thinks we drive trains, and rates our profession a poor tenth when comparing the contribution that groups like doctors, lawyers, farmers, government employees, etc., have made to our standard of living.

The engineers' specialization has likewise served as a psychological block, preventing his freedom of movement from one technical field to another because he was unaware of his abilities, meager as they were in some engineering fields. For instance, many civil engineers did heroic service during the last war as structural engineers in the aircraft industry. But their transition was painful until they

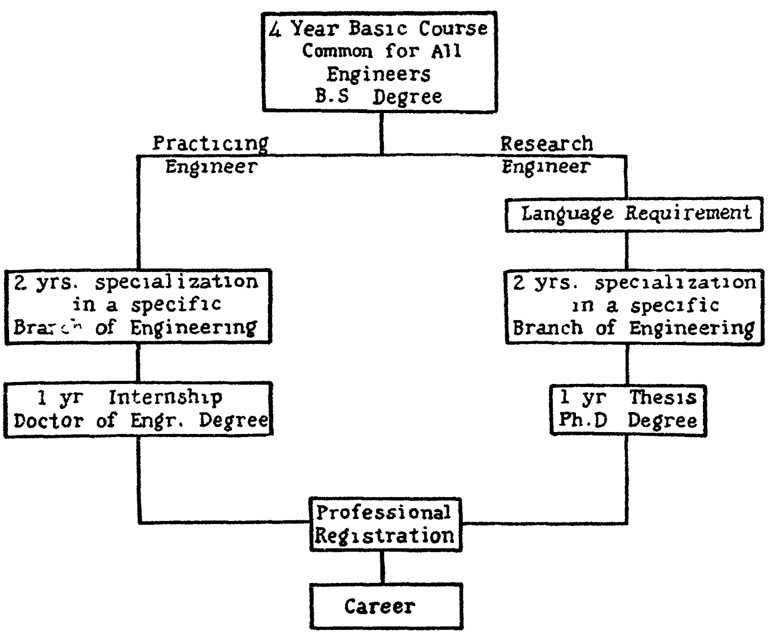


FIG. 1.

TABLE I

	Medicine	Dentistry	Law	Engineering
First Licensing Law	1760	1841	1890	1907
First College Course	1765 (U. Pa.)	1840 (Balt.)	1779 (W. & M.)	1828 (Rensselaer)
2–4 Plan Approved by Prof. Society	1918	1937	1921	?
Founding of Prof. Society	1847 (AMA)	1859 (ADA)	1878 (ABA)	1934 (NSPE)
National Board of Examiners	1892	1883	1931	1920
Prof. Society Accrediting of Curriculum	1907	1909	1921	1936
Licensed Individuals	165,000	77,000	180,000	150,000
Practicing Individuals	165,000	77,000	180,000	350,000
Membership in Professional Societies*	138,000	71,000	42,000	22,000

* Membership restricted to legally qualified individuals.

Data in the Table I represent the best available information. Individual entries give statistical data for the 1940–50 decade, but do not necessarily coincide for any one year. The entries should, therefore, be regarded as being only approximate.

realized the basis of mechanics fundamental to such design in any engineering field.

I am not one who believes that engineers could, or should, run this so-called civilization. Our *first duty* is to *train technically* competent engineers, but early specialization tends to obscure our overall *technical* responsibility of safeguarding public safety and health. Our machines freed man of slave labor but maimed some because safety measures were installed too late. We prolonged man's life by refrigerating his food and purifying his drinking water, but our industries then polluted the air he breathes and the streams in which he swims. We "de-skilled" workers and wondered why they no longer took pride in workmanship. We improved our productive efficiency and were accused of the "speed-up."

Undergraduate Program

The foregoing thoughts may explain in part the somewhat unorthodox program proposed in what follows. First, in order to correct our tendency toward over specialization in the first few years of professional education, I believe these should be generalized technically so as to give all engineers the broad *working* base in the several branches of engineering which industry seems to favor. This curriculum is outlined in Table II. Note that mathematics has been increased beyond calculus to include ordinary and partial differential equations, advanced calculus, vector analysis and perhaps an introduction to tensors. This added training would facilitate and streamline the teaching of advanced technical and graduate subjects. With this background, a four year graduate would then again to able to digest the more advanced papers now published in his own field. Few four year graduates today are able to read highly mathematical papers currently included in the ASCE, AIAS, and ASME Transactions. Similar training in all basic engineering science would likewise increase one's pro-

TABLE II

BASIC FOUR YEAR ENGINEERING CURRICULUM

	Quarter	Credits
I—Cultural Subjects		
A—English (Composition, Rhetoric, Public Speaking, Technical Writing, Literature)	18	
B—Humanities (History, Philosophy, Psychology, Economics, Law)	21	39
II—Sciences		
A—Physical Science (Chemistry, Physics, Geology, Mats. of Engr., Metallurgy)	32	
B—Mathematics (Algebra, Trigonometry, Anal. Geom., Calculus, Differential Equations, Advanced Calculus)	40	72
III—Engineering		
A—Sub Professional (Drawing, Desc. Geometry, Surveying)	12	
B—Professional		
a—Mecahnics; Strength, Fluid Mechanics; Structural Analysis	22	
b—Design of Structures and Machines	15	
c—Electricity—AC, DC and Electronics	15	
d—Heat Transfer—Thermo., etc.	15	
e—Production, Personnel Management, etc.	15	
f—Electives	15	109
		220
GRADUATE TRAINING (C.E.—Example)		
IV—Fifth Year		
A—Transportation (Highway, Railway, Water, Airports, Pipeline)	9	
B—Sanitary (Water Supply; Sewage Disposal; Bacteriology, Hydrology; Water Analysis, Microscopy)	12	
C—Surveying and Mapping (Topographic; Route; Photogrammetry; Geodesy; Law)	9	
D—Construction (Estimating; Soil Mechanics; Cost Accounting; Specifications)	12	
E—Design (Indeterminate Structures; Design; Water Power)	12	54
V—Sixth Year—Design Option		
A—Elasticity and Plasticity	12	
B—Vibrations	9	
C—Fluid Mechanics	9	
D—Tensor Analysis		
E—Electives	10	45

ficiency in these specialties. Civil Engineers, for instance, are using electronics for triangulation in surveying and depth gaging of harbors. Electronic devices are fast becoming controlling factors on production lines. An understanding of electronics is essential to all—not proficiency for tube or circuit design, but plain conversant knowledge.

Design could likewise be taught on a completely revised basis by emphasizing the basis of mechanics and using illustrations from all fields in the simple design of machines, buildings, planes, vehicles, etc. Heat transfer could cover the thermodynamics, not only of perfect gases and vapors, but also of liquids and briefly of solids.

Since engineers must assume technical and administrative leadership in industry, it seems absolutely essential to include some training in this field too. 'Tis often

said, "leaders are born—not made." It helps to be born gifted, but the principles of leadership are well known and can be taught. They have in fact been taught at our own Military and Naval Academies for years. Why not at civilian schools too?

Successful completion of such a course would leave an individual well qualified to pass preliminary examinations for the professional engineer's license, and to improve by individual study in any technical field of his own choosing—if he had the determination. He would be well trained for future administrative work. Subsequent academic work should, I feel, be split into one of two categories here but admission should be restricted. The man interested mainly in research could then pursue and earn a Ph.D. Degree as he does now (Fig. 1). For the practicing engineer, and most engineers practice and seldom engage in real research, I believe the alternate plan outlined below would be more suitable.

Graduate Program

Supplementary specialized instruction should follow the four year program in another two years of study. The first of these would allow coverage of the several fields of a particular branch of engineering. One electing civil engineering for instance, would study the broad fields of sanitation, surveying and mapping, transportation, construction and structural design. The sixth year would then be devoted to a further specialization of one of these, such as structures, and include elasticity, plasticity, vibrations, fluid mechanics, and highly indeterminate structures.

Successful completion of these additional two years of professional training would entitle the individual—not to the necessity of pursuing a thesis in some narrow field—but to a broad internship. He would visit large industrial and governmental research laboratories for perhaps several months, and gain a better insight into overall research programs and techniques than by conducting his own thesis. He would also be apprenticed to production managers and corporation presidents as their special assistants for short periods of time to see how the "top brass" operates. He would spend some time on construction jobs, on production lines and in design rooms.

This period should be labeled an internship for this word has been already accepted by the public as connoting completion of an academic professional course of study, and initiation of professional practice under *legally* qualified practitioners.

A treatise on this internship marking the seventh year, embodying consideration of technical and human problems should entitle a man to the Doctor of Engineering Degree. I do not feel that titles like C.E., etc., suffice in the public mind, for our own colleges have been too prone to vary the standards in the past for this degree. Some schools had, and still do have, very rigorous standards † for a Professional Degree, but none require a seventh year of internship to my knowledge. Furthermore, the public now considers a doctorate title synonymous with true professional stature.

These seven years of training would then allow a candidate to obtain his professional license without difficulty, and examining boards could waive the usual four year in-training periods. Industry might still not trust the judgment of these inexperienced products with top positions of responsibility, but the public at least might think of them as professional individuals.

The suggested program with its four year course, two years of graduate work, a year's internship, a Doctor of Engineering Degree and Professional License might encourage the public to grant engineering its merited professional stature.

† Stanford and M.I.T. have six year courses.

An Interpretation of the Manifesto*

By C. J. FREUND

Dean of Engineering, University of Detroit

The cooperative system of engineering education has grown up; has even attained middle age. The cooperative colleges of engineering have adopted a statement of policy, and that proves the maturity of the system.

A manufacturing corporation, a university, a club, even a new government, almost any type of enterprise, seems to develop according to a familiar pattern. In the early years the enterprise displays great vitality. The operators are eager and exuberant, although they make mistakes and are less efficient than they might be. In time the first enthusiasm wears off a little, and the operators begin to suspect that they had better mingle wisdom and thought with hard work and optimism. Problems arise which they did not notice at the start, or which did not exist. The operators seek formulas to assure permanence and stability.

After some trying years of experience and experiment, they construct basic rules to guide them when they encounter such complex difficulties that simple and obvious solutions are impossible. By the time the operators have drawn up these basic rules—we call them policies—and especially after they have published them, the public is quite certain to recognize that their enterprise is firmly established.

The cooperative colleges have published their policy, and consequently the cooperative system is a firmly established institution. The statement of policy is called "The Cooperative System—a Manifesto." The Cooperative Engineering Education Division of the Society adopted the policy in its meeting at St. Louis in 1946, and it was published in the JOURNAL OF ENGINEERING EDUCATION for October of that year.[1]

It is this Manifesto which we shall consider for a few moments.

The Selection Process

We hardly need to go over all of the Manifesto: besides, there isn't time enough. We had best confine ourselves to a few topics in the Manifesto which pertain especially to what is going on at the moment in engineering employment and in engineering education. And we might as well begin by looking at the cooperative plan from the viewpoint of the man who hires the boys who graduate from our colleges.

Every employer is concerned, of course, about working capital, sales, an efficient plant, good will and the like. But every intelligent employer knows very well that he can survive in competition only if his men are more competent than the average of his competitors' men. Hence it is that recruiting officials who visit the colleges are always looking for graduates of superior talent and personality.

How does the recruiting official usually select the graduates? All of us know the procedure. The student may write a letter of application. He may fill out a form with detailed information about his education, career and background. He may complete an aptitude or psychological test. He may have a fifteen minute interview with the recruiter, during which he can hardly be quite himself. And the

* Presented before the Cooperative Engineering Division of the ASEE at the Annual Meeting, University of Washington, June 19–23, 1950.

[1] XXXVII, 117–34.

recruiter may inquire about him of the professors or of the college placement officer. Occasionally he may spend a day or two inspecting the prospective employer's plant or visiting in his home office. This way of doing it is as effective as circumstances permit, in most cases, and reflects high credit upon the judgment and the resourcefulness of the recruiting officials. But the method is comparatively superficial, and it couldn't be otherwise on account of its inherent limitations.

As explained in the Manifesto, the employer of cooperative students does not have to depend upon letters of application, ten minute interviews and aptitude tests when he hires graduates. He chooses them after a trial period of employment in his plant, and he is quite likely to pick the right men. He has had the opportunity to observe their practical intelligence at work, which is something quite different from schoolroom proficiency. He can find out if they maintain their interest in his employees and his plant after the first novelty has disappeared. He can discover how they get along with engineers, superintendents, foremen, and workmen, including those with cantankerous dispositions.

Experience and Practice

Now I suggest that we fix our minds upon that most pleasing phenomenon, the superior student. We all know the type. He is a joy to his faculty, a leader among his fellows and a challenge to the recruiters who come around. Let us assume that this superior student gets a class assignment to design a fan and a motor to ventilate and remove moisture from an underground storage space. After some weeks the boy turns in the design. The professor checks the amount of air and water the fan can handle, the blade contours, the selection of bearings, the brackets and their capacities, the material specifications and much besides. He finds that all are quite correct and the boy gets a grade of A.

This class design is good enough, as far as it goes; it is acceptable within itself, so to speak. But nobody investigates whether it meets a number of external requirements, and nobody can, in a college of engineering.

The practicing or employed engineer has to worry about matters which the student, or even the professor, may never think about. Will the fan be noisy? Will it vibrate badly? The engineer may not find out until the first one is built. He has to specify materials which are readily available, and he had better know that they will continue to be. He will have a hard time defending forged blades in a plant equipped principally with presses. The pattern and foundry superintendents may go into an uproar about the cost of making up the brackets. The engineer must try to introduce parts into his design which are in production already for other purposes and regularly kept in stock. And most important of all, he must design something which the customer wants, and for which he is willing to pay enough to cover all direct and indirect costs, and a reasonable profit.

It is practically impossible to include any of these considerations in a college design course: there are some things one just has to learn by experience. And this is only one very ordinary example of the countless practical requirements and limitations which have to be recognized in every branch of engineering practice.

Cooperative employment is one way, and an excellent one, for students to acquire the practical outlook. After some months of employment in a machinery building shop, the cooperative student instinctively knows that good design requires much more than functional performance and simple specification of materials. Of course, cooperative employment is not the only means to this end. Students in continuous, conventional colleges of engineering may gain practical experience during summer vacations, or after they graduate, but most of them don't. It is never easy to find just the right kind of summer job, and parents,

doting aunts and uncles, and girl friends frown upon manual work after graduation; and so do the boys.

The Problem of Assimilation

Engineering graduates encounter jealousy and pride of status when they "break into" shop or office. It is hardly to be expected that the practical veteran and the technically trained upstart will get along together. The veteran fears that the upstart will overreach him by superior education; the young engineer fears that the veteran will thwart him as a highfalutin outsider.

The cooperative system is a natural solution of the problem. The old timer really does not resent the young engineer's getting to the top of the ladder, provided he climbs in regular succession from each rung to the next. What the old timer does resent is any attempt by the engineer to outsmart his less fortunate fellows who have to depend on steady labor to reach the top.

The cooperative student has been a workman in the plant. His fellow employees have seen him operate machine tools or presses, repair hoists, rebuild open hearth furnaces or engage in common labor. If his speech and deportment are judicious they may not even know that he is a student. If he is later promoted to an engineering or supervisory job, they are likely to concede that he has earned the promotion by a proper apprenticeship. Indeed, they may even be proud of him as one of their own who has made his mark.

Science and Engineering

It is easy for the cooperative student to understand the difference between the engineer and the scientist.

The scientist became the civilian hero of the war, and has remained a popular American hero ever since. Scientific research won the war, we are told. But engineers had a large hand in the business. In fact, the scientist without the engineer is helpless to create machines and structures. However, the writers, lecturers and commentators have spun so much glamor about the scientists that many engineers wish they were scientists, and some of them rather imagine that they are at least semi-scientists.

This, of course, is a mistake. The functions of the two are altogether different. The scientist explores for new information or knowledge; the engineer applies the new information or knowledge to improve the standard of living in the community. The scientist experiments in heat, dynamics and metallurgy, and deposits the reports of his findings in the libraries of the world. The engineer reads the reports and makes use of the information to design and construct a more efficient Diesel or jet engine. The scientist is essentially a thinker and a scholar; the engineer is essentially a maker, an operator and an administrator. The scientist and the engineer are quite distinct, although in the every day working world it is not always easy to know which is which.

But the engineering student has to learn which is which. If he is afterwards to perform his proper function, he certainly must know just what that function is.

The cooperative student in shop or engineering department learns to appreciate the engineering operations which result in the brightly painted rotary pumps, switchboards, machine tools or excavators waiting in their crates on the shipping platform of his plant. And he naturally concludes that altogether different operations result in documented research reports on the library shelf. It does not take the cooperative graduate half a lifetime to understand his place in the scheme of things.

Conclusion

Let me repeat that this has not been intended by any means as a review of the whole Manifesto. It has been intended merely to suggest how the Manifesto bears upon two matters which have captured the attention of engineering em-

ployers and educators: the assimilation of young engineers to their first employment, and the accelerating ascendency of science.

In conclusion, perhaps we should remind ourselves that the cooperative method of engineering education has no unique, major objectives of its own. The auxiliary objectives, and obviously the procedures of the method, differ from those of the conventional, continuous colleges, but the basic aims are the same. The American Society for Engineering Education has adopted scientific-technological and humanistic-social aims for engineering education. We all know them very well. They were published in the JOURNAL OF ENGINEERING EDUCATION for March, 1940.[2] To quote from the Manifesto, "The cooperative colleges of engineering accept these aims, and declare them to be their own."[3]

[2] XXX, 563–64.
[3] *Op. cit.*, 119.

Candid Comments

My attention has recently been called to an error in the article "Visualization of Fundamental Principles in Elasticity Using Rubber Models" in the May issue of THE JOURNAL OF ENGINEERING EDUCATION. A correction would make this report of considerably more value to others.

The rubber compound used in making a model is said to consist of natural rubber, 28.5%; fillers, 57.3%; vulcanizer, 8.6%; sulfur, 3.1%; oils, 3.5%. Converted to 100 parts of rubber, the basis used by rubber chemists, this becomes rubber, 100; fillers, 201; vulcanizer, 30.1; sulfur, 10.8; oil, 12.3.

If the term vulcanizer is used to mean accelerator and the amount shown is correct, the compound is impractical. These materials are seldom used in excess of 1 to 2 parts and never in amounts as high as 30 parts. The amount of sulfur used is excessive and will result in poor physical properties in the vulcanized compound. The amounts of oil and fillers are also unnecessarily high.

Yours very truly,

RALPH F. WOLF

Manager, Compounding Research, Pittsburgh Plate Glass Company

Results of Questionnaire Regarding Graduate Degrees in Chemical Engineering

By THOMAS E. CORRIGAN

Assistant Professor of Chemical Engineering, West Virginia University

In a recent survey of several graduate schools in Chemical Engineering, a questionnaire was sent out to ascertain current policies in the granting of the Master's and Ph D. degrees in Chemical Engineering. This is a brief summary of the results of the survey.

Of the schools reporting, nine require a qualifying examination for candidates for the M.S.Ch.E. degree, and fourteen departments have none. The subjects covered in those schools requiring qualifying examinations are varied. In the majority of cases the examinations cover undergraduate and graduate chemical engineering courses and, in addition, the student's minor subject (where a minor is required). Some of the specific subjects covered are: Unit Operations, Industrial Chemical Calculations, Stoichiometry, Applications of Physical and Organic Chemistry to Chemical Engineering and Chemical Technology. The time allowed for the examination varies from four to twelve hours. Of the nine schools reporting use of the qualifying examination, six use a written examination and two have an oral one. In one department, both a written and an oral examination is given.

The policies seem to be fairly uniform in the requirement for a Master's thesis. Seventeen of the schools reporting require a thesis and in three others a thesis is optional but highly recommended. In three additional institutions none is required.

In the schools where both Master's and Ph.D. degrees are given, four require that the candidate obtain a Master's degree as a prerequisite to the doctorate. In four other departments this procedure though not required is highly recommended. In fifteen colleges the M.S. degree is not required as a prerequisite. Thus, there is some difference in procedure in this requirement.

The departments are fairly evenly divided in the matter of splitting the student's program into major and minor subjects at the Master's degree level. In nine schools the student must so divide his course work. In two others, this method is recommended but not required. Twelve departments do not require the division into major and minor fields.

For the Ph.D., however, sixteen schools divide the student's courses into major and minor fields, and three do not. Of this sixteen, five require two minor fields. Four of the schools replying to the questionnaire do not grant doctorates in Chemical Engineering.

Only one institution allows complete freedom of choice to the student in selecting his course. Twenty-one of the schools have a program in which some of the courses are required and some are left to the choice of the student under faculty supervision. In one institution the choice of the student's courses is made by the staff.

In conclusion, it should be noted that the sampling of the schools was small because only 55% of the questionnaires sent out were returned. However, the replies represent a cross-section group both from the points of view of size of the institution and section of the country. It is hoped that this summary will be useful as a step toward greater uniformity of standards in graduate schools in chemical engineering.

Laboratory Demonstration Experiment—A Link between "Fundamentals" and "Applications"

By D. ROSENTHAL and H. BAER
Department of Engineering, University of California, Los Angeles

1. *Introduction:* One of the avowed purposes of Engineering Education appears to be the teaching of the fundamental physical and chemical principles and laws as they apply to the engineering practice. In accordance with this purpose the student is first exposed (usually in the sophomore and junior years) to various courses, such as Mechanics, Strength of Materials, Thermodynamics, etc. in which the emphasis is on Fundamentals. To be sure the Fundamentals are slanted toward engineering applications, but the latter are generally treated as illustrations of methods of solution rather than as an aim in itself. The true applications come later. They are the subject of separate courses (usually in the senior year) known as: Structural Design, Machine Design, Unit Operation, etc. Not only are the Fundamentals and Applications taught separately, but as a rule they are taught by different instructors. This in itself is not a bad practice provided the two groups of instructors see eye to eye and work as a team. In the past the teamwork left much to be desired. In the cases in which the "Fundamentals" were treated with the necessary mathematical rigor they were entirely ignored in the "Applications," partly because the instructor in charge scorned at the "highbrow" mathematics, partly because he had more faith in his experience than in the underlying principles. As a result the student left the school under the impression that the "Fundamentals" were just a mental drill necessary for the attainment of the degree, but with no relation to the practice of the engineering profession. Under the impact of modern science this attitude no longer exists either with the instructor in charge of "Applications" or the student, but the necessary link between the "Fundamentals" and "Applications" is often missing in the instruction. A point in case is the relation between "Strength of Materials" and "Machine Design." It has been the authors' experience both as instructors and students that in the mind of the student only a tenuous link exists between these two subjects. To be sure the student

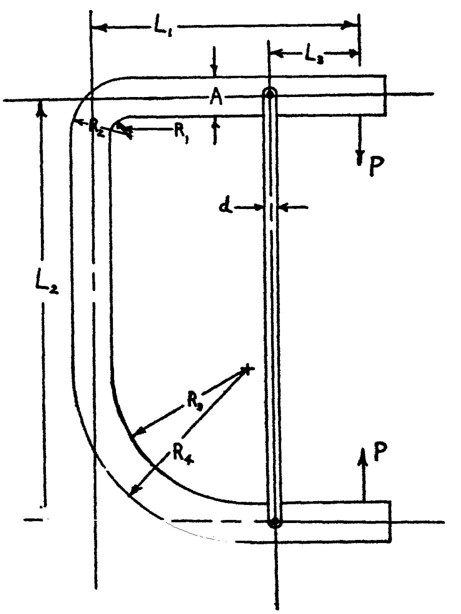


FIG. 1.

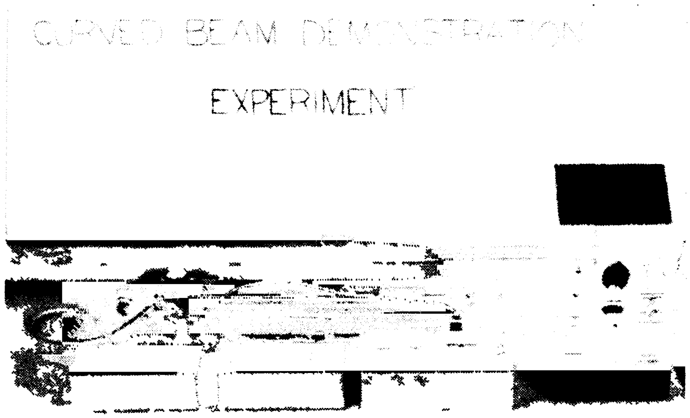


FIG. 2.

knows that the design of some of the machine parts is based on formulas of "Strength of Materials," but he is usually unaware of their limitations, and he is generally incapable to apply the methods which lead to these formulas. As a result, he is at a loss to explain the discrepancies between theory and experiment or assess the limits of the experimental error, when faced with the results of actual measurements. It is the authors' opinion that the cause of this deficiency lies in the lack of a proper transition between the "Fundamentals" (as taught in the sophomore and junior courses) and the "Applications" (as given later in the laboratory and senior courses). To correct this shortcoming an attempt has been made to provide the necessary transition by means of a scheme described below

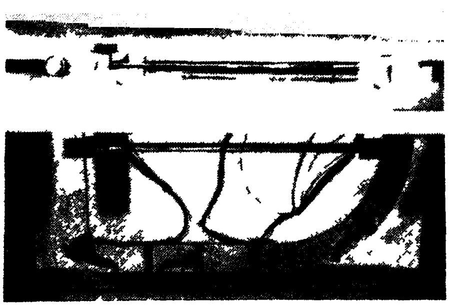


FIG. 3.

2. *The Laboratory-Demonstration Experiment:* The scheme consists of having the student solve a problem at various stages of idealization: from its theoretical inception to its industrial realization.

In the first stage the problem is in the nature of a computation. It is merely an application of principles and laws expounded in a theoretical course. In the second stage the analytical solution is obtained experimentally on a model reproducing all theoretical assumptions as closely as possible. In the third and final stage the experiment is carried out on an existing industrial system or machinery. This last step no longer forms a part of the "Fundamentals." It appears in a later year as a part of "Applications," and the experiment is performed not as a check of the theory, but as an inspection or test of the system or machinery.

The first and third stages of the scheme are not new. They have been improved continually. Thus, in the first stage classroom demonstrations, sometimes of remarkable simplicity,[1] and devices for visualization of great ingenuity [2,3] have been

[1] R. S. Hartenberg, *J. of E. E.*, Vol. 40, p. 430.

[2] A. J. Durelli, C. H. Taso and R. H. Jacobson, *Ibid.*, p. 525.

[3] A. D. Moore, *Journal of Applied Physics*, Vol. 20, p. 790.

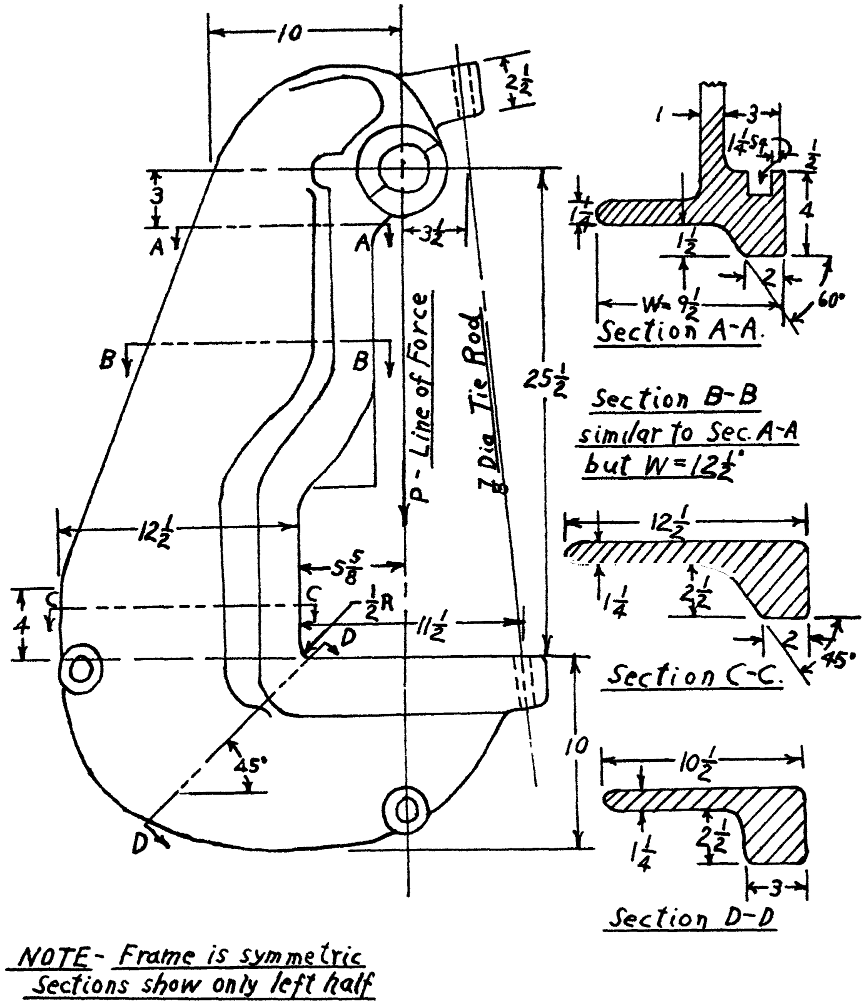


FIG. 4.

employed. The third stage was sometimes developed into highly complex and organized systems, e.g., in some power plant experiments.[4] But neither stage is believed to accomplish the aims of the second stage to which more specifically the name of "Laboratory-Demonstration Experiment" has been given. These aims are of a threefold nature:

1. From the experimental solution the student gets the real feeling of the quantities and methods involved in an otherwise abstract mathematical solution.

2. By comparing the computed and measured values on the basis of the experimental error he can assess for himself the validity of the principles and laws involved in the theory.

3. When dealing with an actual system or machinery he is in the position to account properly for the discrepancies resulting from the idealization of real conditions.

An example of the scheme just described

[4] M. J. Zucrow, *J. of E. E.*, Vol. 38 p. 482.

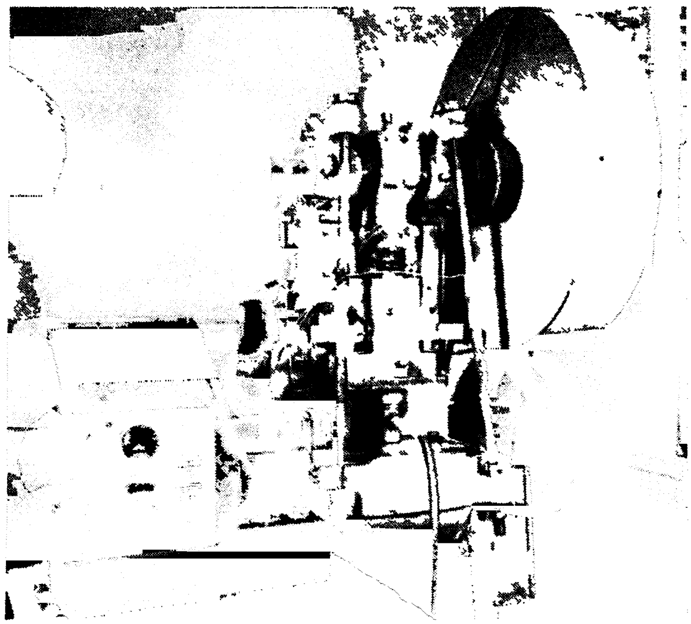


FIG. 5.

is given below. This example has been in use for about two years. It is still somewhat premature to speak of the results. That much appears certain: in order to serve its purpose the Demonstration-Laboratory Experiment must be conceived in such a way that it can be operated by the student at any time and without supervision. That is, the student must be given time and opportunity to make mistakes and to correct them himself, much the same as in his homework.

If it is agreed that the ability to idealize the real conditions forms a part of the engineering *thinking*, and the ability to account for the observed discrepancies a part of the engineering *judgment*, then the proposed scheme accomplishes its purpose.

3. *Example: Stress Analysis of a Punch Press Frame.*

First stage. Problem of strength of materials:

"Computation of Stresses Produced in the Frame Sketched, Figure 1."

Educational purpose: Application of the following principles and theories:

a) Equilibrium of forces and moments. Free body diagram. Method of section.

b) Principle of virtual work (or equivalent).

c) Beam theory (curved and straight beam).

d) Principle of elastic stability (column buckling).

Second Stage. Testing of an idealized system:

"Experimental Determination of Stresses Produced in the Frame, Figures 2 and 3."

Educational purpose: Verification of:

a) Hooke's Law. Establishment of linear relation between applied load and measured strain.

b) Bernouilli's Law. Establishment of linear and hyperbolic strain distribution in the straight and curved parts of the beam.

c) Analytical solution. Determination of the influence of sharp and mild corners.

d) Validity of the theory on the basis of the experimental error. Confidence in the experimental stress analysis.

Third Stage. Testing of actual machinery:

"Determination of Safe Operating Loads in the Punch Press, Figures 4 and 5."

Educational purpose:

a) Idealization of the behavior of the punch press frame for the purpose of a theoretical analysis.

b) Explanation of discrepancies between observed and computed values on the basis of

1) assumed idealizations,
2) assumed mechanical characteristics.

c) Use of Goodman-Johnson (or equivalent) fatigue diagram for the determination of safe operating loads with and without the tie rods.

d) Significance of stress raisers at sharp corners from the point of view of design.

e) Improvement of efficiency by:

1) residual stress (prestressing of tie rods),
2) modification of design (rounding of sharp corners),
3) substitution of a welded for cast frame.

f) Consideration of rigidity (influence of the deformation of the frame on the tolerances of the punching operation).

In the News

Eleven national technical societies and one from Canada have already taken formal action to participate in the international convocation which will celebrate one hundred years of engineering as an organized profession in the United States. This convocation, organized under **Centennial of Engineering,** 1952, is designed to "Provide an opportunity for all engineers to gather to exchange ideas and information of value to one another with no one group taking a place of special prominence."

At a meeting, on October 12, 1950, the incorporators of Centennial of Engineering authorized President Lenox R. Lohr to extend invitations to an additional sixty technical societies in this country, and to appropriate societies of international scope, or of national scope in other countries. The international societies will be invited to hold their annual meetings in Chicago during the Centennial Convocation from September 3 to 13, 1952.

Some Current Practices in Teaching Advanced Composition for Engineers

By MAURICE L. RIDER

State Teachers College, Indiana, Pennsylvania

A limited survey recently completed at The Ohio State University reveals a variety of facts about current practices in teaching English composition for advanced students in engineering.[1] The survey was made by sending questionnaires to thirty-five leading technical schools and colleges of engineering throughout the United States. Of those institutions responding to the questionnaire, twenty-one offered courses in advanced composition for engineers.[2] The facts reported by those twenty-one institutions are here summarized for what significance they may have for teachers of advanced composition in other technical schools and colleges of engineering.

The administrative requirements reported for advanced-composition courses show considerable variation. Quarter hours of credit offered range from two to six, with a minimum of one hour of recitation each week for eighteen weeks to a maximum of three hours of recitation each week for twenty weeks. One course devotes no time to student-teacher conferences, but others allow from one-half hour to three hours of conference time per quarter for each student. Medians computed from the data submitted show the following characteristics for a typical course: quarter hours of credit, 3; clock-hours of recitation, 43; duration of the course in weeks, 16; and average amount of conference time devoted to each student, 2 hours.

Responses to the questionnaire revealed a total of eleven different objectives for the twenty-one courses. The following recapitulation indicates the number of courses for which each of the objectives was listed: (a) to develop proficiency in the correct use of the fundamentals of English (grammar, spelling, punctuation, etc.), 17 courses; (b) to impart skill in writing technical reports, 14; (c) to teach the correct forms of engineering reports, 13; (d) to foster effective writing, 10; (e) to develop skill in writing business letters, 7; (f) to perfect the student's ability to organize data, 5; (g) to teach library research techniques which culminate in effective reports, 4; (h) to foster the writing of articles acceptable to leading professional and technical magazines, 3; (i) to promote clear thinking, 2; (j) to give students help in their current writing for other departments, 1; and (k) "to encourage the student in widening his mental horizons and gaining proficiency in the expression of ideas outside his immediate professional field," 1. The principal objectives of the twenty-one

[1] The survey appears as part of the author's dissertation, "Advanced Composition for Students in Engineering at The Ohio State University: Evaluation and Proposals," Columbus, 1950.

[2] These schools were Brooklyn Polytechnic, University of Colorado, Georgia Institute of Technology, Illinois Institute of Technology, University of Illinois, Massachusetts Institute of Technology, University of Minnesota, Missouri School of Mines, New York University, University of North Carolina (Raleigh), Oklahoma A. and M., Pennsylvania State College, Princeton, Purdue, Rensselaer Polytechnic, Stanford, Texas A. and M., University of Texas, U. S. Naval Academy, Virginia Polytechnic, and University of Washington.

advanced courses in composition for engineers may be summarized as follows:

(1) to teach the student to write correctly and effectively the reports and business letters that may be required of him in his professional career, and (2) to teach him to think clearly and organize his work logically.

Replies to the question on the kinds of written work required indicate a total of nineteen different types of original composition. Twenty courses require the writing of one or more kinds of technical reports and fifteen require business letters. Since these two general types of composition may be further subdivided, they are given separate treatment in Tables 1 and 2. Technical expositions of processes and mechanisms are required by ten courses, and the library research report is required by seven. Five courses require the writing of definitions, and four require abstracts, outlines, and descriptions as well as personal data sheets to accompany letters applying for positions. Three courses afford the student practice in writing technical articles suitable for magazine publication, while the compilation of a bibliography and the writing of editorials and book reviews are each a part of the program in two of the twenty-one courses. Other types of original composition required in but a single course are as follows: advertising copy, formal direction sheets, interpretations of graphs and diagrams, news stories about technical subjects, and occupational analyses of the students' chosen fields.

TABLE 1

TYPES OF BUSINESS LETTERS REQUIRED IN COURSES IN ADVANCED COMPOSITION

Type of letter	Number of courses giving instruction
Application for a position	10
Sales letter	8
Letter of transmittal	7
Response to an inquiry	6
Adjustment letter	5
Letter of inquiry	5
Letter of instruction	4
Letter report	4
Inter-office correspondence	3
Order letter	3
Letter of authorization	2
Collection letter	2
Credit letter	1
Recommendation	1
Letter inviting a speaker	1

TABLE 2

TYPES OF TECHNICAL REPORTS REQUIRED IN COURSES IN ADVANCED COMPOSITION

Type of report	Number of courses requiring each type
Progress	8
Descriptive or informative report	6
Examination	4
Analytical	3
Inspection	3
Recommendation	3
Completion	1
Periodic	1

Of the fifteen kinds of business letters which were listed for the twenty-one courses, the letter of application for a position is most frequently required. The sales letter, the letter of transmittal, and the letter responding to an inquiry follow the letter of application in order of frequency. The adjustment letter and the letter of inquiry are each required in five courses, and the letter of instruction and the letter report are required in four. Other types of letters and the frequency with which they were listed appear in Table 1.

Table 2 lists the eight kinds of technical reports taught in the twenty-one courses in advanced composition. The table was made by disregarding the possibility of duplications in nomenclature and listing the name of each kind of report as it appeared on the questionnaires.

The teaching method which instructors in advanced-composition courses reported most effective is the following five-step

procedure: (1) Student writing in response to a clear, specific assignment, (2) grading of the papers, (3) discussion of classwide errors, (4) student correction and revision of papers, and (5) special help to students with individual difficulties. Seven of the twenty-one instructors who filled out the questionnaire mentioned this method specifically—even to the point, in some instances, of outlining the procedure. Ten teachers mentioned the correction and discussion of student papers, and six said they insisted upon and supervised the student's correction and revision of his papers. Class discussion and study of student and professional models antecedent to student writing are elements of the method which were mentioned by seven teachers. Thus thirty of the forty-two responses on classroom procedures dealt wholly or in part with the inductive method of teaching written composition.

The remaining twelve responses that concerned teaching methods were divided among seven different procedures. Each of the following methods was mentioned by two instructors: (1) The work in English is directly related to the student's professional courses. (2) Arbitrary good forms for letters and reports are dictated by the instructor. (3) Opaque projectors are used to show models of student and professional work to the class. (4) Informal lectures on specific writing problems are presented to the class. Each of the following methods was mentioned by one instructor: (1) Lectures on composition problems are given by other members of the faculty and by prominent industrial leaders. (2) Writing assignments are designed to be done in class. (3) Papers and reports of local and individual character are assigned to prevent plagiarism.

While the number of courses from which the preceding data were assembled is too small to provide a representative pattern, the survey does indicate a few of the commoner practices in teaching advanced composition for engineers. In aim and content the courses are primarily practical; that is, they teach the student how to do the writing he will have to do as a practicing engineer. The engineering report, business letter, professional article, and the abstract are the forms most frequently taught. In addition, attention is generally given to the mechanical and structural requirements basic to all effective writing, and the implication is that a part of this training is remedial. The prevailing teaching method requires the student to examine good models, apply the information to new and practical composition assignments, submit his written material for criticism, and carefully revise his manuscript on the basis of the suggestions he receives.

Beyond these few common elements of purpose, content, and method, advanced courses in technical composition vary widely. Their diversity generally reflects the academic background of which each is an integral part, rather than any fundamental disagreement about the functions of courses in technical writing.

Resolution of Thanks

The American Society for Engineering Education duly assembled at its 58th Annual Meeeting in Seattle, Washington on June 21, 1950 wishes to express its sincere gratitude and appreciation to James S. Thompson for his faithful and untiring efforts as Treasurer of the American Society for Engineering Education during the highly critical period since 1942.

His wise counsel and broad experience have been of inestimable help to the Council, Executive Board, and the entire membership of the Society.

Environmental Engineering Aspects of Nuclear Activities*

By ARTHUR E. GORMAN

Sanitary Engineer, Division of Engineering, Atomic Energy Commission, Washington, D. C.

In any discussion of the technology or even the economic potentialities of a new industry, experience has indicated the importance of giving consideration to the environmental impact of that industry. Such consideration is of particular importance if the industry's operations, its products or its wastes are in any way objectionable to community living or hazardous to public health. Environmental problems of industry are of special interest to sanitary and public health engineers because the public has over the years come to these specialists for advice in matters affecting their environmental interest. The purpose of this paper is to present from the viewpoint of the sanitary engineer, some of the environmental problems in the atomic energy industry, emphasizing particularly the obligation of and opportunity for educators in the engineering profession to participate in helping this new industry to enjoy a healthy growth without encountering some of the needless growing pains that other industries have experienced.

Experience of other Industries

Looking in retrospect over the problems which have been associated with the growth of industry in the United States insofar as its impingement on community life, public health and safety and the economics of the local or regional area of operations were concerned, it is quite clear that many mistakes were made. In the light of previous experiences, many were avoidable, some may have been made in ignorance; still others were made because an industry developed far beyond the most optimistic concept of its founders in its influence in the economic or community life of the immediate area or the nation.

For example, many years ago with the realization that theirs was an industry noxious to community life, the stockyards and packing house interests in Chicago moved to an area beyond the city limits. In the course of events, however, the growth of the city exceeded expectations and soon the stockyards and packing houses were surrounded by residential and commercial developments. As a consequence, a whole series of environmental problems arose to plague the industry and the public. Again in the case of the automotive industry little did its founders realize when the first car was built how profoundly in the years to come the automobile would affect the economic structure of the nation, revolutionizing transportation and setting the stage for such great industries as road building, oil refining and rubber tire manufacture. It is doubful if the pioneers in the automotive industry realized that clean streams in which fish were then abundant, would in the years ahead become grossly contaminated by wastes from the new industry they had started; or that the clean invigorating air over the manufacturing areas would become polluted by objec-

* Presented at Fall Meeting of the Engineering College Administrative Council, American Society for Engineering Education, Kansas City, Missouri, October 28, 1949.

tionable dusts and fumes from theirs and allied industries.

These examples of the environmental aspects and potentialities of a new industry could be multiplied many times. But, they will serve to illustrate the depth, the variety and the types of problems which the sanitary and public health engineers of this country have had to face in working with industry; also to point out to members of this association who are interested in the education of engineers, some of the considerations which need to be weighted in appraising professional opportunities and obligations in the fast growing atomic energy industry.

Atomic Energy Industry Different from other Industries

The atomic energy industry differs in many respects from other industries with which we are familiar; but still in matters of environmental sanitation certain patterns are similar; others are new—even unique. Insofar as this new industry differs from others, educators of personnel for this industry will want to adapt training programs to these needs. It may be helpful to refer to some of the areas in which normal American industries differ from the atomic energy industry in organizational and operating policies involving environmental sanitation and public health.

Most industries are privately-owned and are operated subject to the laws of the state in which they are operated. Their raw materials are diverse and their finished products are widely distributed through established competitive channels; waste products which have value are generally promptly reclaimed and those without value before being released are subject to such treatment as public health officials having jurisdiction require. Specialists in such industries working with public officials have helped to develop techniques and procedures for operating controls affecting the public, and together they have arrived at reasonable agreement as to levels of contamination in wastes from various industries which can be disposed of to nature without creating a nuisance or a public health hazard. Usually wastes from normal industries, even though they may be objectionable or hazardous, are short-lived and their environmental effects can be observed in terms of hours, days or weeks.

In contrast, the atomic energy industry by law is federally controlled; knowledge of its operations are subject to strict security controls; there is no profit motive in its commercial operations; the raw materials such as uranium ores are rare and costly and may be imported from distant places; techniques and procedures in processing are unique; the finished product is highly radioactive as are some of the wastes; and, standards or permissible tolerances of contamination for wastes released to nature vary widely within the industry and are unfamiliar to most outside public officials. There are few state or local regulations governing the disposal of these wastes, especially those that are radioactive. This is because so little is known by outside agencies concerning such wastes; and finally, some of the wastes of this industry may be long-lived and if not handled correctly present problems for both present and future generations.

Problems of Waste Disposal

In view of what is already well known about the atomic energy industry, it is obvious that its products are hazardous and must be handled with intelligence and care. The same is true of its waste products. The Atomic Energy Commission is giving much consideration to this aspect of its operations. The principal hazards arise from the effects of radiation, but some products also have toxic properties. Starting with the mining of raw materials from which fissionable material is obtained, and continuing on until the product is prepared as fuel for nuclear reactors, protection against low levels of radiation can usually be obtained by good industrial housekeeping

as practiced in well-controlled chemical industries. After the fuel materials are bombarded by neutrons the level of radioactivity is increased and from then on exceptional methods must be taken both to protect workers in the industry and to prevent products or wastes from exposing others off-site to hazardous amounts of radiation or to wastes which are toxic. Such precautions are taken and responsibility for this work has fallen on a new group of specialists known in the industry as health physicists. They have been and are doing a good job and deserve much credit for the control measures which have been put into effect.

Problems of environmental sanitation exist in dealing with toxic and radioactive wastes especially when the amounts and levels of activity are high. As with other industries, waste products to be disposed of may be in solid, liquid or gaseous forms. Unfortunately, the problems of disposal in any of these forms are by no means as simple as in other industries. Standard equipment and established methods of treatment are not always usable with radioactive materials, especially those of high energies and long half-lives. For example, equipment used in handling radioactive materials may have to be taken out of service because of the high level of radioactivity it has acquired and not because it has worn out. Ordinary maintenance tanks may require special shielding to protect workers and in the design and installation of equipment special consideration must be given to this aspect of the industry. It is in developing new solutions to these problems that chemical and sanitary engineers are needed in the atomic energy industry whose training in nuclear physics is adequate to permit them to keep abreast of the research and developmental work carried out by the nuclear physicists. The new products or methods developed in research must ultimately be engineered for production units and these should include auxiliaries for treatment and disposal of wastes. This is true whether we are dealing with applications of atomic energy for civilian or military applications.

Initially, the principal objective of the atomic energy industry in this country was to develop a military weapon; and to a large extent its energies are still being directed toward military objectives. During the war, naturally, production had a priority over considerations of waste disposal, although these were not neglected. An appraisal of waste disposal problems in the post-war period has shown, however, the need of improved methods of treating wastes, and as the atomic energy program expands, disposal facilities are being developed and installed. Already today, industrial plants in many states assist in processing nuclear fuels for the atomic energy industry, and radioactive materials are shipped to and from widely scattered production areas. Radioisotopes are being used in research institutions in about 40 states.

The Atomic energy industry is not as fully integrated into the American community and economic system as are most other industries. The original plants and laboratories at Oak Ridge, Tennessee; Hanford, Washington; and Los Alamos, New Mexico were specifically located in isolated areas and its employees were housed in federally controlled villages. In matters of environmental sanitation this situation has its obvious advantages and disadvantages. Isolation of production plants and laboratories is desirable from the standpoint of security and certain potential environmental hazards especially in disposal of wastes. Isolation of research areas has the disadvantage of distance from institutions cooperating on related research and readily available reservoirs of trained technicians and other workers. As a latecomer in the American industrial field, the atomic energy industry faces the problem of adjusting its operations to those of an organized economy and established ways of community life.

It is of fundamental importance that the site on which a plant for production of nuclear products be carefully selected

from the point of view of such environmental factors as: (1) distance from other industries or communities; (2) availability of an adequate source of water supply; (3) effect of products or wastes if accidentally released on sources of ground or surface water supplies; (4) meteorologic conditions in the area and general vicinity; (5) topography and geology of area in relation to security and structural factors; (6) availability of housing and community facilities; (7) transportation.

Cooperation with other Public Agencies

One of the important steps found in integrating this new industry into the national pattern has been in calling upon other public agencies for assistance in the fields of their special interests, proficiency and responsibility. This involves indoctrination of their experts in operations of the atomic energy industry and in turn getting from them judgments arising from experience in dealing with many other industries over the years. In matters of environmental sanitation such long-established federal agencies as the Geological Survey, the Public Health Service, the Bureau of Mines and the Weather Bureau have been most helpful. The Geological Survey has investigated geology at and in the vicinity of several production and research areas under A.E.C. control in connection with availability of water supply, the effect of disposal of wastes on water resources; and the suitability of soils for disposal of wastes. The Public Health Service with long experience in treatment and disposal of domestic and industrial wastes and pollution of waterways has assigned experts to assist in research in disposal of radioactive and toxic wastes peculiar to the atomic energy industry and in research in methods of removing radioactive decontamination from water. The Weather Bureau has cooperated in numerous areas in study of meteorological conditions affecting operations at production and research plants where the decontamination and release of radioactive gaseous effluents is or may be a matter of concern. In addition to cooperating with these federal agencies in resolving problems of environmental sanitation the prime production and research contractors of the Atomic Energy Commission have and are carrying out important research on waste disposal methods at their various areas of operation. Furthermore, contracts have been made with research institutions to do similar work. Of special interest to sanitary engineers is research being carried on in waste disposal and decontamination of radioactive water, being carried out at the Oak Ridge National Laboratory, Los Alamos, and by the Sanitary Engineering Divisions of the Massachusetts Institute of Technology, New York University and The Johns Hopkins University.

Certain state agencies have also cooperated with the A.E.C. in problems of environmental sanitation. Their participation has been less, not because their assistance is not needed, but principally because there have not been available in these agencies personnel trained in those aspects of nuclear physics which are essential to an understanding of the industry's problems in relation to local responsibilities.

Need of Training Public Officials

To date supervision and control over production, use, transportation and disposal of radioactive materials and wastes have been carried out within the industry with little attention by outside public agencies which normally have responsibility for industrial operations in areas of their jurisdiction. This situation which grew out of wartime security conditions is gradually being adjusted but has continued because among the staff members of such agencies knowledge of nuclear physics and problems of this industry which would be required to exercise normal governmental controls, is lacking. Since it is quite obvious that the atomic energy industry is here to stay and that

it will be widely developed to serve our citizens, it is important that knowledge concerning this industry should be better understood by all, especially those having a direct interest or concern. The Atomic Energy Commission is seeking to broaden the base of knowledge concerning this industry and in this effort educators of engineers can be of great service. The acute shortage of research workers trained in nuclear physics, techniques, instrumentation and interpretation of results has been relieved to some extent by training courses sponsored by the A.E.C. and by some of the military agencies. But, the number of trainees in the engineering field is limited and the industry will continue to be embarrassed in a healthy expansion program until education and training of workers both within and without the industry can be expanded. In particular, there is a need of educating and training public officials who have a responsibility for public health and safety. It is timely to point out that these officials and those operating public utility systems such as water and sewage works also occupy strategic positions in public service.

It is highly desirable if plans for the expansion of the atomic energy industry are to go forward that in matters of environmental sanitation involving this industry, federal, state and local officials be given training in nuclear physics. It is in this connection that the directors of educational institutions can be most helpful. A logical attack on this problem calls for immediate action on two fronts:

1. Training of the young engineer in the making;
2. Training of experienced engineers already carrying public responsibilities and qualified to help the atomic energy industry, but lacking knowledge in nuclear physics and the special problems of the industry.

If we agree that atomic energy has great potentialities for service in this world then the educator of young engineers in all branches of the profession should be given well-balanced instruction in nuclear physics and its applications. In schools offering degrees in sanitary and public health engineering such instruction should be especially thorough. The training should give emphasis to the environment aspects of atomic energy operations particularly in relation to hazards involved in transporting and handling of materials, and in disposal of wastes of all kinds. It should include use of instruments and interpretation of data. Education and training of engineering graduates along these lines will develop in the future a wider understanding of the problems of the atomic energy industry; will permit better balance within the industry of responsibility carried by engineers in the fields of their specialty and in the long run, will permit the industry to become more effectively integrated as a normal unit of our national life instead of an awesome oddity little understood and much discussed.

The training of the older graduate engineers experienced in public service, such as sanitary engineers, geologists, industrial hygienists, water and sewage works specialists and others, in nuclear physics and its applications in research and production in the atomic energy industry presents a complicated problem to engineering educators. It is, however, an obligation which should carefully be appraised and I hope promptly accepted by the American Society for Engineering Education if this industry is to enjoy a healthy growth. Looking at this problem from the standpoint of attaining a firm civilian defense position, action toward initiating training programs should be started at once.

The experienced engineers in the various professional classifications previously referred to have much to offer the atomic energy industry and, where their services have been called upon, this has been amply demonstrated. A great deal of research and development work in water supply and purification, use of water for heat exchange, collection, storage, treatment and disposal of radioactive wastes,

and in the development of special equipment is needed and this demand will continue as the industry grows. Work in this direction is being retarded because of shortage of specialists in these fields who have knowledge of nuclear physics.

It is the writer's opinion that a combined effort by the principal federal public agencies concerned and the directors of engineering education in American colleges and universities, is needed to develop adequate training of these older engineers in order that their usefulness in their jobs and to the atomic energy industry may be fully realized. Some negotiations, looking forward to special training of sanitary and public health engineers, have already been entered into with the National Research Council through its Subcommittee on Sanitary Engineering and Environmental Sanitation. In a three-way cooperative program, as referred to, the public agencies after evaluating their interests in and possibilities for service to the atomic energy industry could select key men for training. In turn, the staff of the Atomic Energy Commission, after being advised of the interests and service possibilities of these outside agencies, could suggest the types of problems in the industry in which the trainee could help most and arrange to establish avenues of approach within the industry which would bring the trainee into realistic contact with these problems. Consultation between the industry, the public agencies and educators of engineers could develop the type of instruction and length of training which should precede, accompany, or follow the trainee's contacts with the industry's operational problems. Through a well-coordinated program of this kind small groups of experienced engineers could be assigned to various A.E.C. areas or educational institutions for practical and theoretical training.

It is understandable that educational institutions look with disfavor on certain types of "short course" training, especially in the basic sciences. But the problem which faces the atomic energy industry in public health and environmental sanitation today are so unique that they warrant special consideration. In conclusion, I am sure your society will want to help the industry through this transition period when the experienced public health engineer, without knowledge of nuclear physics, will be called upon to serve until the young engineer, who is being trained in the fundamental principles on which the atomic energy industry rests, can attain the experience which will permit him to pull a strong oar in meeting the many environmental problems which lie ahead in the growth of this new and important industry.

Surveying Instruction in the Civil Engineering Curriculum*

By HERMAN J. SHEA

Associate Professor of Surveying, Massachusetts Institute of Technology

Probably no other subject in the Civil Engineering curriculum is open to so wide a latitude in continuity, course content, emphasis and time allotment as is Surveying. One of the factors leading to this variation is whether the field work is given during a regular semester, on or near the campus during the summer, or at a summer surveying camp. Another influence on the surveying program is whether field work is taught together with theory or subsequent thereto.

With these deviations in mind it is both impossible and undesirable to present a singular solution for the design of a surveying program. Rather, any treatment must take the form of a description of instructional method adopted by one institution. No claim is advanced that our approach is perfect, but it is the product of much thought and serious consideration.

Certainly a periodic review of course content is both wise and necessary. To keep abreast of recent developments and to include them in the curriculum with proper emphasis should be the aim of every surveying instructor. However, it is patent that new material is being constantly introduced into the Civil Engineering curriculum. Thus time and subject allotments within the surveying program are complicated by the twin pressures of new material and decreased time. To design carefully under such conditions calls for careful judgment leading to the best and wisest use of the actual time available.

A major precept which governs the arrangement of our surveying program at M.I.T. is that students, when in normal succession, will have completed all their surveying subjects by the end of their sophomore year. It is our feeling that by so doing, the student is presented with a definite advantage when seeking summertime employment. Not only will their chances for sub-engineering positions be heightened, but the student will be better able to benefit from such practical experiences.

Since the first-year program at M.I.T. is identical for all students irrespective of course selection, one of our curriculum requirements for surveying is that all subjects be scheduled between the end of the freshman year and the end of the sophomore year.

Summer Surveying Camp

Students are introduced to surveying through attendance at the Civil Engineering Summer Surveying Camp at East Machias, Maine. It is presumed that these students have had no descriptive or theoretical course in Surveying. We are then committed to a program of instruction combining description, theory and practice. In my personal experience at M.I.T., I have had the opportunity to compare those students who have taken a theory course before attendance with those who have had none. It has been my personal finding that the latter group adjusts itself quickly,

* Presented at The New England Section Meeting of the ASEE, Yale University, October 8, 1949.

has forgotten nothing, for there is nothing to forget, and in the course of a relatively short time, finds itself in the same position as those with previous instruction. A class room description of an engineer's transit followed by an interval of four to eight months before using the instrument impresses me as a waste of time. Terms hazily understood and unreinforced by actual usage are not apt to stay in the student's mind over long periods of time.

Our initial work at Camp is devoted to training the student in the handling of the various instruments and practice in elementary surveying methods. We aim, at the end of two practice rounds, to develop the student to the point where he may, counselled by the instructor, participate in the survey of an area and concentrate his attention on the problem at hand without being distracted by major questions of technique.

Since, to my mind, the first steps in a fieldwork subject are important toward setting the pace of the course, I should like to describe in some detail the work of the first few days. The first morning at Camp is divided into three lectures—lectures on a grouping which I like to think of as the optical instruments of surveying; the plane table and alidade, the engineer's transit and the engineer's level. Our first round of fieldwork is devoted to one day's practice in each of the above instruments.

With the plane table and alidade, the student carries out the principles of intersection, resection and the three-point problem using range poles on a comparatively level stretch of land. Thus the student is able to see, at one glance, the translation of these points onto his plane table sheet. To avert the impression that these methods are adapted to ranges of 300–400 feet, the operations are repeated on a preplotted plane table sheet to a scale of 1/20,000 using control stations roughly two miles away. During this work, the student is naturally becoming acquainted with the handling of a plane table board and tripod, orientation of a map sheet, and manipulation of the telescopic alidade.

The remainder of the plane table exercise consists of observing a plane table traverse having about ten sides. This project provides the student with a graphic introduction into the general subject of traverses. Likewise he is able during the first time he runs a traverse to have a visual record of his error of closure—a point that should start him thinking about precision. A third novel feature, to the student, is the reading of distances by the stadia method.

The student's work with the engineer's transit starts with his setting a transit over a point and reading single angles on distant targets. These observations are conditioned, naturally, by the requirement that the sum of the angles totals 360°. To point out the advantage of checking each angle as it is measured and to show how superior precision may be obtained, the student immediately reobserves the same angles by the method of repeating each angle three times. If the student is required to maintain a check between his first repetition and the average from his third reading, the certainty with which the sum of the angles will depart by only small values from the theoretical amount should serve to show him the value of observing local checks whenever possible.

The exercise devoted to the engineer's level consists of running levels between established benchmarks. These runs are designed to be short enough to permit each student to observe a known difference of elevation. Thus a check of his effectiveness is immediately available.

Second Group of Exercises

Our second round of preliminary exercises is prefaced by a series of three lectures on contours, principles of stadia and taping. As before, these discussions are followed by one-day exercises in the location of contours by use of the plane table, a day on observation of a stadia traverse and a third day on taping.

In the first exercise, that of contour determination by use of the plane table, the student spends the first half-day chasing in contours by means of a level telescope and the second half-day taking vertical angle stadia shots and interpolating the contours. Thus the student should see the topography grow on his plane table sheet and he should early acquire a feeling for contours.

The stadia traverse project provides the student with his most complex instrument technique and party organization to date. Our traverses consist of 12-sided figures, each starting point near a benchmark and provided with a variety of sights. By carrying elevations and azimuths, checking foresights by appropriate backsights, the student hopes to insure a reasonable closure. I can well attest to the student's feeling of concern when the closing point is reached.

Taping, as we well know, is simple in theory and difficult of practice. The student starts by taping a line about 800 feet long, forward and backward, by horizontal t aping. We require an apparent agreement of one part in 10,000 between the two measures. Much care is taken to impress upon the student that this agreement is apparent only and that temperature effects and erroneous length of tape undoubtedly influence his result in far greater amount than his agreement. As a prelude to vertical angle taping, the student observes by horizontal taping the distance between two points at the top and bottom of a steep banking. He is then more than ready for vertical angle taping. This latter method shows the student an efficient means of securing distance measurements where the difference of elevation is great.

We place much importance on these preliminary exercises for we feel that a student properly grounded during this series is ready for large scale practical problems. It is, of course, true that he should be constantly improving the quality of his workmanship, but the introductory phase should be over.

In groups of six, the students are assigned to instructors to perform the complete mapping of an area approximately 1000 feet square. A control traverse is run to a specified precision of one part in 5000. This traverse is laid out to serve most efficiently as control for the final map. Vertical control is next established with temporary benchmarks near each traverse station. After satisfactory sun azimuths are obtained and the traverse computed, a plane table sheet is prepared. This manuscript map serves as a record for topography taken with the plane table and the transit stadia information is plotted thereon. We attempt to secure about one-half the topographic information directly through the use of the plane table and the other half by transit stadia.

Each student is required to prepare a finished map of his area. Much as we may admire maps drawn in colors on heavy white paper, the fact must be faced that virtually no engineering office would allow the time necessary to prepare such artistic triumphs. We therefore specify that the student's effort be done on tracing cloth with ink. The map must not only be accurate, carefully drawn and pleasing from an engineering standpoint, but it must be efficiently executed.

In the first portion of our work at the Summer Surveying Camp, there are naturally many items of instruction which are properly part of the work. I should like to mention specifically two particular subjects. One is the observing of stars for time, latitude and azimuth. While the former two observations are relatively infrequent in engineering practice, the student who is able to handle his instrument in the dark with the aid of unsatisfactory illumination is well along the way toward mastery of his subject. Of course, observations on Polaris for azimuth have has a distinct bearing on the practical execution of surveys.

The satisfactory teaching of instrument adjustments is, to my mind, an important feature of surveying instruc-

tion. Our practice is to require the student to test the instruments (transit, level and alidade) which he had been using in the field and to report on their condition of adjustment. By this means he becomes familiar with the errors. He is then handed an older transit and level purposely put out of adjustment and is told to come back with the instruments in perfect working order. By providing the student with older instruments, the damage is somewhat confined.

Advanced Program

The second portion of the Surveying Camp (three weeks out of a total of seven) is allotted in equal parts to Route Surveying Fieldwork and to Advanced Surveying Fieldwork. In the former, the student meets for the first time that broad division of Surveying which we might call layout work. Previously he has been engaged in analytical measurements on quantities already in place. That the staking out of structures is important and a wide field of practical surveying, no one will deny. Why not, therefore, lay stress on this at an earlier date and to greater extent? Our feeling is that the student must first have a thorough background in the handling of his instruments and in the methods of surveying to permit a concentration of attention on the efficient solution of his layout problem.

Regardless of the project, whether it be a highway relocation, an earthwork estimate, a column or building location, an important point that should be kept in mind by the student is that construction survey points have a high degree of mortality. We feel that adequate instruction must be given to working along offset lines and that efficient references well outside the construction area be included in the survey.

One noteworthy feature of this type of survey is that the scope of the project should be, on the one hand, of sufficient size to stimulate a sense of accomplishment, and on the other, limited enough that the completed survey be easily visualized.

In Advanced Surveying Fieldwork, our purpose is to introduce the student to some of the more precise methods of surveying. Briefly, the projects covered are: angles with a repeating instrument, directions with a micrometer microscope theodolite, base line measurements with a 50-meter tape and stakes, precise traverse with a 100-foot steel tape and taping bucks, and precise levels with a tilting dumpy level. Within the scope of this course, stream volume measurements and soundings are also covered.

While the major emphasis of our Camp curriculum is on fieldwork, theoretical discussions are held whenever necessary to an adequate understanding of the problem at hand. We find that we are able to cover the entire subject matter of such an elementary book as "Breed's Surveying" as well as numerous excursions into higher surveying.

Upon his return to the Institute, the Civil Engineering student registers for Advanced Surveying in the fall semester and for Route and Construction Surveys in the spring. In both of these courses, the work at the Summer Surveying Camp is continued and amplified. Wherever possible, fieldwork data taken at the Camp serve as problem material.

It is with the former course—Advanced Surveying—that I am particularly concerned and I should like to present some of the features of that course. In the recitation part of this course, engineering astronomy, base line measurements, triangulation, and precise leveling are covered in some detail. Likewise, instruction in State-wide rectangular coordinate systems is included.

Astronomy

The teaching of Engineering Astronomy is a case in point where the decreased time allotment has had a major impact. To present in a limited time the full scope of Practical Astronomy to a student is well nigh impossible. Such a

course might well be a full term's work. We have adopted the compromise of grounding the student carefully in the basic definitions and then develop the Greenwich Hour Angle system as a practical approach for problems wherein time enters. Such a development has the virtue of simplicity and may be comprised in a much shorter time.

An adequate coverage of the Lambert Conformal Conic and the transverse Mercator projections as adapted to Statewide rectangular coordinates is, to my way of thinking, extremely important. We develop sufficient theoretical background for an adequate understanding of these systems, but concentrate considerable attention in showing the student how such layouts are adaptable to routine surveys.

The drafting room section of this course is devoted in equal portions to the solution of engineering problems by use of contour maps and to photogrammetry. In the former, an attempt is made to introduce the student to the various fields of Civil Engineering through assigned projects. Thus Hydraulic Engineering is met by way of the determination of a watershed area and the volume of the resulting impoundment; Sanitary Engineering by the design of a sewer system for a land development; Transportation Engineering by grading considerations for a highway and an airport; and Structural Engineering through a bridge triangulation problem. True the projects are both simplified and without the complex details which are properly part of a complete design. But there is much to show a student and such an early introduction, we feel, is not amiss.

Concerning the teaching of Photogrammetry to Civil Engineering students, I have some definite ideas. As a generalization, I feel that instruction in this subject is most certainly part of a Civil Engineering student's training in Surveying. But I do feel that the guiding thought should be to show the students what use they, as potential engineers, can make of aerial photographs with only limited equipment; and secondly to point out what specialized companies in this field can do for them. A listing of our projects in photogrammetry should give some idea of what I feel belongs in the former category. These are:

1. Preparation of a flight map
2. Preparation of an index map
3. Geometry of a vertical aerial photograph-displacement due to relief and tilt
4. Radial line plot—two flight lines, 10 prints of an area in the vicinity of our Summer Surveying Camp where adequate control is available
5. Complete preparation of a planimetric map based on Project 4—detail transferred by use of vertical reflecting projectors
6. Scale check problem, vertical print —coordinates taken from a print, altitude of exposure found, and length of a second line determined (the latter measure is compared with a known length giving the student an indication of the precision of the process)
7. Tilt of an aerial photograph from scale check lines
8. Height of an object, such as a stack, from a stereo-pair
9. Preparation of a stereo-pair for contouring
10. Examination of stereo-pairs for detailed information

The above listing omits the various instruments which are appropriate to the projects. Such equipment as lens and mirror stereoscopes, vertical reflecting projectors, height finders and stereocomparagraphs should be available. There is, of course, considerable lecture work necessary to the introduction of the above projects.

In developing this paper, the thought has occurred to me at this stage that I have concentrated on a design for what (it is my fond hope) should be a technical excellence on the part of the stu-

dent. Yet there is much more to the training of a student in Surveying. Throughout this subject there is an excellent opportunity to inculcate professional and ethical responsibilities. Since the result of a survey is highly flavored by the character of the parties concerned, there is no readily applied criterion to judge the accuracy or completeness of the product. Those standards which we are in a position to apply must be both technically and ethically sound. Redesign of our courses has been necessary, but any arrangement must include the facts and ideals of life. For surveying, these include education leading to a competent workman who does a professional piece of business.

ECPD News

Better engineers, fitted for the increasing tempo of technical progress and developed through more efficient use of the first five years following graduation, is the objective of a long-term program announced by the Engineers' Council for Professional Development. The study is the result of more than 15 years of work on the part of the E.C.P.D. Committee on Professional Training under the chairmanship of A. C. Montieth, Vice President of Westinghouse Electric and Manufacturing Company. Essentially it is a guide which assumes that a young man with potential, and whom the report characterizes as "the most important person in this country today, is willing to contribute heavily in time and effort toward his own development. The engineers picked the five years following graduation as the most important in a professional man's life, since he is then on his own and if the period "can be filled with a helpful program, the further progress of developing the engineer will be a natural evaluation." The committee felt that if, within the first five years, the young engineer did not organize his thinking and see through the complexities of modern industrial life, he would not be able, eventually, to assume leadership.

The E.C.P.D. program is divided into five parts. The first covers the orientation and training of engineering personnel by employers. The committee studied the training programs of 54 companies and reviewed the published information about programs of about 80 other industrial firms. The study showed that the cost of industrial training was minor, and that results after the first year usually held enough promise to convince management that further development and further training were wise. The committee characterizes industrial training as "the first and best opportunity to start the young engineering graduate on a professional development program."

The second part outlines plans for cooperation in industrial and engineering schools for the continued education of the graduate engineer. "Industrial management must do more than provide orientation and specialized treatment," the committee report states, "it must be concerned with the education of the whole man and employers in industry and government, in cooperation with the colleges, have the responsibility of providing continued education for the engineering graduate." A way of meeting this responsibility was suggested by a subcommittee which surveyed various study programs and found that out of 50 industrial centers, some 23 offered evening study opportunities for engineers through local colleges. For those communities that have no local engineering school, they recommended that local engineering societies encourage industry and the state universities to establish extension centers; that the engineering societies sponsor refresher courses, round-table discussions, and lecture series in specialized fields of interest to the community.

The third section of the report dealt

(*Continued on 191*)

Report of ASEE Mechanics Division Summer School, Iowa State College

More than one hundred interested teachers of Mechanics attended the five day Summer School on Dynamic Teaching of Mechanics held at Iowa State College, September 11–15, 1950. Thirty-nine institutions were represented in the registration list.

The first day was devoted to background material with an examination of the learning process by Dean Kerekes, a discussion of the historical development of mechanics by Dean Hollister and a consideration of the prerequisite material in mathematics and physics by Dr. Cell. Each of the following days was devoted to a consideration of the course content and techniques of effective teaching of one of the four subjects, Statics, Dynamics, Mechanics of Materials, and Fluid Mechanics. In one evening session Dr. Grinter presented results of some experiments in teaching methods for non-average students and Professor Muhlenbruch outlined the use of teaching aids in presenting the work in mechanics. Slides of a number of teaching aids and a movie on a presentation of mechanics were shown. Examination techniques was the subject of another evening meeting, at which time Professor Howe gave a survey of types of examinations and methods of grading.

One feature of the Summer School which received considerable favorable comment was the amount of time left available for discussion. Approximately three hours were allocated to each session with one, or in a few cases two, scheduled speakers. At least an hour was available for general discussion of each of the topics, thereby giving all who were interested an opportunity to participate. Many excellent discussions were presented from the floor.

At the closing dinner on Friday evening Dr. Warren E. Wilson, President of the South Dakota School of Mines gave an excellent address on "Mechanics—The Foundation of Philosophy." Inspection trips were scheduled to several of the Laboratories and in addition the Synchroton and College TV Station were visited by interested groups.

Condensations of papers and discussions are scheduled to appear in the issues of the Mechanics Division Bulletin during the forthcoming year.

ECPD News

(*Continued from 190*)

with the relationship of the neophyte engineer with his community. The committee stated that the engineer has a certain responsibility to his community since the public has "made a great investment in him through the taxes and endowment funds provided for higher education. Too many young engineers, particularly in the last few years, have been concerned with the 'rights and privileges' rather than with the obligations and responsibilities which the pursuit of the profession entails," the report stated.

For guidance in integrating the engineer with the community, the committee surveyed present practices and found no cohesive program yet developed. To overcome this, the group said that the responsibility rests first with local sections of engineering societies; second with

(*Continued on 195*)

THE T-SQUARE PAGE

Devoted to the Interests of Engineering Drawing

J. Gerardi, *Editor*
University of Detroit

Mid-Winter Drawing Division Program—ASEE
Texas A. & M. College

COLLEGE STATION, TEXAS

January 18, 19, and 20, 1951

The Agricultural and Mechanical College of Texas (Texas A and M) is celebrating its 75th Anniversary during 1950–51. The Drawing Division was invited to hold its Mid-Winter Meeting at College Station, Texas, during the annual meeting in Seattle. The Executive Committee accepted the offer and fixed the dates of January 18, 19, and 20, 1951. The tentative program includes:

(All Meetings in Memorial Student Center)

Thursday, January 18, 1951

7:00 A.M.–6:00 P.M.	Inspection trip to Humble Oil and Refining Company (Gasoline refinery, butadiene plant, and rubber plant); new ship channel tunnel; San Jacinto Monument; Battleship Texas; National Biscuit Company; new $100,000,000 Houston Medical Center; etc. Meet in lobby at 6:45 A.M.
7:30–10:00 P.M.	Dinner Meeting of the Executive Committee. Meet in lobby at 7:15 P.M.

Friday, January 19, 1951

8:00–8:30 A.M.	Registration
8:30–10:00 A.M.	Open House—Engineering Drawing Department (Anchor Hall).
10:00–12:00 Noon	Conducted tours of Texas A and M.
12:15–1:15 P.M.	Drawing Division Luncheon. Greetings from the College, President M. T. Harrington. Response, Professor Ralph S. Paffenbarger, Chairman, Drawing Division of ASEE.
1:30 P.M.	Division Program "The Design and Development of the Agricultural Airplane"—Fred E. Weick, Research Engineer and Distinguished Professor of Aeronautical Engineering, Texas A. & M. College. "Drawings for Jigs and Fixtures"—Homer Briggs, Reed Roller Bit Company, Houston, Texas. "Drafting Problems Encountered in Structural Steel Fabrication"—R. M. Sherman, Central Texas Iron Works, Waco, Texas.
6:30 P.M.	Dinner Meeting Music—Bryan High School Acapella Choir. Humorous—"The Future We're Headed For It," Cayce Moore, The Nation's Most Famous Barber. Speaker—"The Future of Plastics," Elgin B. Robertson, Texas Professional Engineer.

Saturday, January 20, 1951

8:00 A.M.	Descriptive Geometry Film—Evaluating Committee: 1. Professor J. H. Porsch, Chairman Engineering Drawing and Descriptive Geometry, Purdue University. 2. Professor C. C. Perryman, Engineering Drawing Department, Texas Technological College. "Technical Drawing Curriculum Leading to a Bachelor of Science Degree"—Professor H. C. Spencer, Director, Technical Drawing Department, Illinois Institute of Technology. Discussion: Professor A. S. Levens, Division of Engineering Design, University of California. "A Re-examination of the Methods of Teaching Basic Drawing"—Professor H. L. Henry, Mechanical Engineering Department, Louisiana Polytechnic Institute. Discussion: 1. Professor R. M. Coleman, Department of Engineering, Texas Western College. 2. Professor R. P. Hoelscher, Head Department of General Engineering Drawing, University of Illinois.

A ladies program is being planned.

This is the program as of early October, 1950, when copy was submitted to the T-Square Page. The final program with blanks for hotel accommodations for advanced registration will be mailed members of the Drawing Division in December, 1950.

College Station is on State Highway No. 6, half way between Waco and Houston.

Reservations are to be returned to Professor B. F. K. Mullins, Engineering Drawing Department, Texas A & M College, College Station, Texas.

New Members

ANDERSON, CLIFTON A., Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. E. B. Stavely, E. Baldwin.

BENTLEY, MARK W., Instructor in Engineering Drawing, Mississippi State College, State College, Miss. H. P. Neal, C. P. Marion, Jr.

BEROZA, PAUL P., Assistant Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. C. Lewis.

BIEGEL, JOHN E., Instructor in Industrial Engineering, University of Arkansas, Fayetteville, Arkansas. H. W. Risteen, G. F. Branigan.

BLANKLEY, ROY EARL, Instructor in Engineering Industrial Arts, University of New Mexico, Albuquerque, N. Mex. M. C. May, R. J. Foss.

BRADBURY, DONALD, Associate Professor of Mechanical Engineering, Rhode Island State College, West Kingston, R. I. T. S. Crawford, F. W. Hoye.

BRAND, RONALD S., Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. F. L. Castleman, C. H. Coogan.

BROCKENBROUGH, THOMAS W., Assistant Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. E. B. Norris, F. C. Morris.

BROUGHTON, DEAN C., Assistant Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. J. S. Rising, J. A. King.

COVAULT, DONALD O., Instructor of Civil Engineering, University of Colorado, Boulder, Colorado. W. Raeder, H. H. Kelly.

ECKERT, KERMIT, Instructor in Electrical Engineering, California State Polytechnic College, San Luis Obispo, Calif. E. C. Glover, C. E. Knott.

EAGER, MARCY, Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

FAIRBANKS, GUSTAVE E., Associate Professor of Agricultural Engineering, Kansas State College, Manhattan, Kansas. F. C. Fenton, L. E. Conrad.

FEAD, JOHN W. N., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, S. D. E. E. Johnson, R. D. Anderson.

FRANCE, EDWARD L., Assistant Professor and Head, Automotive Department, Utah State Agricultural College, Logan, Utah. F. Preator, J. E. Christiansen.

FRANKEL, JACOB P., Assistant Professor of Engineering, University of California at Los Angeles, Los Angeles, Calif. W. L. Orr, C. M. Duke.

GATES, NEWELL L., Director, Technical Institute, Franklin University, Columbus, Ohio. J. T. Faig, D. E. Deyo.

GISSER, DAVID G., Instructor in Electrical Engineering, Rensselaer Polytechnic Institute, Albany, N. Y. W. C. Stoker, L. P. Winsor.

GREAVES, MELVIN J., Associate Professor of Civil Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, H. R. Kepner.

GROVER, KINGMAN N., Instructor in Humanities. The Cooper Union, New York, N. Y. W. B. Embler, R. W. Cumberland.

HAAS, VINTON, B., JR., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. K. L. Wildes, G. Timoshenko.

HANNA, WILLIAM J., Assistant Professor of Electrical Engineering, University of Colorado, Boulder, Colo. G. Dobbins, H. H. Kelly.

HAUSMAN, PAUL G., Professor and Chairman, Engineering Shop Practice Department, University of Kansas, Lawrence, Kans. K. E. Rose, A. S. Palmerlee.

HENDRICKS, IRA K., Director of Libraries, Utah State Agricultural College, Logan, Utah. F. M. Dawson, A. B. Bronwell.

HENNICK, DONALD CUMMINS, Assistant Professor of Mechanical Engineering, University of Maryland, College Park, Md. S. S. Steinberg, R. B. Allen.

HEWITT, GEORGE S., Associate Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. D. D. Lingelbach, G. H. Scott.

HOBSON, MERK, Assistant Professor of Chemical Engineering, University of Nebraska, Lincoln, Neb. H. T. Bates, J. H. Weber.

HOLLISTER, CLAY H., Professor and Head, Engineering Administration, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, H. R. Young.

ISRAELSEN, ORSON W., Professor of Irrigation and Drainage, Utah State Agricultural College, Logan, Utah. F. M. Dawson, A. B. Bronwell.

KEMP, A. B., Instructor in Welding, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

KLUTE, DANIEL O., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, J. L. Meriam.

KOLINER, RALPH, Associate Professor of Civil Engineering, University of Pennsylvania (Towne School), Philadelphia, Pa. E. F. Stover, D. T. Harroun.

KRAVETZ, ADAM J., Lecturer in Electrical Engineering, University of Toronto, Toronto, Ontario, Canada. G. F. Tracy, L. S. Lauchland.

KULESA, WALTER E., College and University Relations, General Motors Corporation, New York, N. Y. R. F. Moore, K. A. Meade.

LARSSON, ROBERT D., Assistant Professor of Mathematics, Clarkson College, Potsdam, N. Y. W. J. Farrisee, E. McHugh.

LINDEROTH, L. SIGFRED, JR., Professor of Mechanical Engineering, Iowa State College, Ames. Ia. F. Kerekes, J. F. Downie-Smith.

MAGUIRE, JACK H., Instructor in Civil and Architectural Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, H. H. Kelly.

MAJOR, COLEMAN J., Associate Professor of Chemical Engineering, University of Iowa, Iowa City, Ia. K. Kammermeyer, F. M. Dawson.

MALCOLM, DONALD G., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, E. C. Keachie.

MERKLEY, CHARLES N., Associate Professor of Woodwork and Building Construction, Utah State Agricultural College, Logan, Utah. J. Conlam, F. Preator.

MERRIAM, ROBERT W., Instructor in Electrical Engineering , Swarthmore College, Swarthmore, Pa. H. M. Jenkins, W. E. Reaser.

MOSHER, RAYMOND F., Associate Professor of Electrical Engineering, University of Vermont, Burlington, Vt. L. F. Shorey, H. M. Smith, Jr.

NOREEN, ALFRED E., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. J. A. Henry, R. J. Martin.

NYMAN, ROSS A., Instructor in Woodwork and Building Construction, Utah State Agricultural College, Logan, Utah. F. Preator, J. Conlam.

OSORIO, STRUVE L. A., Associate Professor of Sanitary Engineering, Harvard University, Cambridge, Mass. S. S. Steinberg, A. B. Bronwell.

PAINTER, WILLIAM D., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, C. R. Ownbey.

PLATT. EDWARD K., Assistant Professor of Engineering Drawing, Michigan State College, East Lansing, Michigan. O. W. Fairbanks, D. M. Fullmer.

REESE, LYMON CLIFTON, Assistant Professor of Civil Engineering, Mississippi State College, State College, Miss. D. M. McCain, E. D. Myers.

ROBERTS, J. KENT, Assistant Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. V. A. C. Gevecker, L. Hershkowitz.

ROLLINS, JOHN P., Assistant Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. E. McHugh, M. G. Mochel.

RUSSELL, LILY L., Director, Placement Center, University of Houston, Houston, Texas. L. J. Castellanos, W. B. Lowe.

SCOTT, NORMAN R., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. L. E. Williams, G. Timoshenko.

SCOTT, RONALD E., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

SHAW, G. MERRILL, Assistant Professor of Metalwork, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

SHILLING, GEORGE D., Assistant Professor of Engineering, Kansas State College, Manhattan, Kansas. A. O. Flinner, H. T. Ward.

SHIRLEY, JOHN W., Dean, Basic Division of the College, North Carolina State College, Raleigh, N. C. J. H. Lampe, J. W. Harrelson.

SKILLING, HUGH H., Professor of Electrical Engineering, Stanford University, Stanford, Calif. E. Grant, D. H. Young.

SNYDER, NORMAN F., Senior Teacher, Engineering Section, General Motors Institute, Flint, Mich. H. M. Dent, L. C. Lander.

STEIN, ROBERT, Assistant Professor of Electrical Engineering, City College of New York, New York, N. Y. C. Froelich, H. Wolf.

STERK, ROBERT P., Instructor in Petroleum Engineering, University of Houston, Houston, Tex. L. J. Castellanos, W. B. Lowe.

STRAIGHT, D. ARTHUR, Lecturer, Management and Personnel, Newark College of Engineering, Newark, N. J. C. H. Stephans, F. N. Entwisle.

STRAIT, JOHN M., Instructor in Engineering, Eastern New Mexico University, Portales, N. M., R. S. Paffenbarger, C. E. MacQuigg.

SULLIVAN, THOMAS M., Engineer of Airports, Port of New York Authority, New York, N. Y. W. S. LaLonde, J. M. Robbins.

SWENSON, DAN H., Instructor in Woodwork, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

SZEGO, GEORGE C., Assistant Professor and Head, Chemical Engineering, Seattle University, Seattle, Wash. O. M. Klose, C. F. Gerald.

THIBODEAUX, MURPHY H., Instructor in Civil Engineering, The Rice Institute, Houston, Texas. L. B. Ryon, M. R. Marsh.

THOMSON, CHRISTIAN R., Instructor in Radio, Waite High School, Toledo, Ohio. W. G. Rohr, W. F. Rohr.

TUTTLE, MILTON A., Associate Professor of Ceramic Engineering, North Carolina State College, Raleigh, N. C. W. W. Kriegel, K. P. Hanson.

WILSON, WILLIAM H., Instructor In Engineering Drawing, Case Institute of Technology, Cleveland. Ohio. O. M. Stone, H. R. Young.

WORK, CLYDE E., Instructor in Theo. and Applied Mechanics, University of Illinois, Urbana, Illinois. W. M. Lansford, W. E. Black.

WRIGHT, HAROLD E., Instructor in Mechanical Engineering, University of Dayton, Dayton, Ohio. J. H. Parr, A. R. Weber.

WRIGHT, WILLIAM F., Assistant Professor of Mechanical Engineering, Vanderbilt University, Nashville, Tenn. B. M. Bayer, C. H. Bonney.

178 new members this year

ECPD News

(*Continued from 191*)

various community organizations; third with the employer; and fourth with the young engineer himself. Business and service groups were also urged to develop organized programs to welcome newcomers. "Integrating the young engineer into his community will remain a problem only so long as it is a neglected problem. Only a little thought given to its solution in each community will lead to an effective program," the committee concluded.

The fourth part of the volume dealt with engineering registration laws. The viewpoint of the E.C.P.D. committee was that legal recognition does not constitute professional maturity, but rather represents a minimum requirement for engineers. Full professional development depends on continued study and practice of engineering with recognition of responsibility to associates, employer and the public. The committee places on the shoulders of the engineering societies the responsibilities for providing inspiration to carry individuals far beyond the minimum standards of education and experience which are set by the state.

The final part of the study concerns methods and sample tests to help the young graduate make a self-appraisal of his qualifications so that he can redirect himself to take advantage of the opportunities offered.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1951 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President ....

....

For Vice-President ....
(In Charge of Sections and Branches—two years)

....

For Treasurer ....

....

Signed ....

Title ....

Institution ....

Date ....

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Kansas-Nebraska	Kansas State College	Oct. 13–14, 1950	F. W. Norris, University of Nebraska
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Stevens Institute of Technology	Dec. 9, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	Naval Ordnance Laboratory	Oct. 3, 1950 Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	University of New Hampshire	Oct. 14, 1950	W. C. White, Northeastern University
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13 & 14, 1950	F. H. Thomas, University of Buffalo

Members of the Society are welcome at all Section Meetings

Annual Meeting

MICHIGAN STATE
COLLEGE

June 25-29, 1951

East Lansing, Michigan

Engineering Education and the Requirements of Industry*

By HAROLD S. OSBORNE

Chief Engineer, American Telephone and Telegraph Company

Introductory

What I have to say about engineering education and the requirements of industry is naturally colored by my long experience in the Bell Telephone System. I believe, however, there is much in the experience of the Bell Companies which is similar to that of other big companies in so far as this discussion is concerned.

The Bell Companies have on their staffs about 10,000 graduates of engineering colleges, and since the war have been employing about 750 a year. Engineers are prominent in administrative and operating work as well as in technical work. Of the 230 top operating jobs in the System, including the presidents, operating vice presidents, chief engineers and the other principal officials dealing with all phases of operations, 45 per cent are held by engineering graduates, 25 by other college graduates, and 30 per cent by men who had either no college training or only partial college training.

Let me acknowledge at the outset the help which I have had from twenty-five of the most recent engineering graduates in my own department in deciding what points to include in this discussion. They are all men who, before being invited to join my department, had already indicated unusual ability in their professional work—for the most part, work in the Engineering Departments of the Operating Telephone Companies of the Bell System. These men come from 20 different engineering colleges in all parts of the country. Most of them graduated throughout the decade of the 40's The most recent ones graduated in 1947.

The subject of engineering education and the requirements of industry has been frequently and ably discussed in the meetings of this association. I am in entire agreement with much of what has been said. Accordingly, I shall pass over rather quickly or omit altogether some important aspects of the subject. This is partly a recognition of the vastness of the subject, and partly a doubt of my ability to add much that is new to what has been said already.

General Qualities

In particular, I shall discuss only very briefly the effect of college training on what a man is, as contrasted with the professional tools with which he is equipped. While professional training is important, of far greater importance to the success of the young engineer are his intellectual capacity, his health, and his character.

Of the first of these, intellectual capacity, I will say nothing here. Of the second, health, I will merely comment that in many cases health is an important factor in limiting a man's promotion to increased responsibilities. Health is greatly affected by habits of living. Do the colleges do all they can to help the students appreciate the importance of health and develop healthful habits of living?

* Presented before a joint meeting of the Electrical Engineering Division and Division of Relations with Industry at the Annual Meeting of the ASEE, Seattle, Washington, June 20, 1950.

Character

I am using the term character to designate what is probably the most important of these three components of what a man is. By this term I mean to indicate an aggregate of personal qualities which determine to a large extent a man's influence and effectiveness in working with others. They include integrity of thought, word, and act. They include both initiative and consideration for others, ability to be aggressive in carrying forward the job and at the same time to be cooperative with other people.

I believe it is true in other large organizations as it is in ours that a man's progress in the organization is more frequently limited by his character than by his technical qualifications. There is the man who isn't fully adult and doesn't take responsibility, the man who antagonizes others by assumed authority. There is the timid man who does not defend his position although he is right, and there is the egotist who persists in defending his position after he has been proved wrong. There is the man who thinks of himself more than of the job and the man who tries to get the credit for work done by others. This very incomplete catalog is, I am sure, sufficient to make clear the type of consideration of which I am speaking.

What can the college do about the character, so defined, of their students? A man's character represents his adaptation to the environment in which he finds himself. During four very formative years of a young man's life, the college provides most of this environment. Those boys who have a high degree of adaptability are influenced in a very important way. All are influenced more or less.

To a large extent, the most important influences on character are exercised when a man is acting as a member of a group, not merely as an individual. This means that great importance is to be placed on group activities both inside and outside the curriculum.

I was much interested recently to hear the president of a large engineering college say that the faculty have concluded that the students have too much work in the freshman year. I am disposed to agree that in spite of the tremendous pressure of need to learn more things in the course of the college years, in many cases there would be advantage in a reduction of the hours required by the curriculum. I don't mean by this that the men should be given leisure time. The purpose would be to give the men more time for extra-curricular activities which are disciplined, organized, and helpful in the development of useful traits of character. To bring this about the students probably need as much guidance and help from the faculty and other college authorities as they do in learning calculus or the theory of electrical circuits.

The Humanities

I shouldn't leave the subject of general qualities without a word on the much discussed subject of the humanities. While such courses relate in part to the professional training of the engineer, to a greater extent they relate to the development of his character and his outlook on life. In other words, they relate to general education more than to professional training.

Education is a life-time pursuit. In a four-year course about all that can be done for the student is to make him desire an education, so that he will pursue it after graduation. This is particularly true in an engineering course, where the time available for education, as contrasted with training, is necessarily very limited.

This limitation seems to indicate that the definite aim of the work in the humanities should be inspirational rather than teaching facts. Doesn't this mean doing a first class teaching job in a very limited part of the field, rather than making a broader and more superficial coverage. I believe the inspiring nature of the work is far more important than the amount of ground covered or the amount of time devoted to these subjects.

The Professional Tools of the Engineering Graduate

So much for the effect of the engineering college on the general characteristics of the graduate. I will now say something about his professional training.

It is an axiom that engineering education should be directed toward the fundamentals of professional engineering work. As a background for discussing these fundamentals, I should like to review briefly the kind of work done by the engineer.

Generally speaking, the engineer today does not need to be a draftsman nor a skilled mechanic. If he has this need in a specific case, it is because of the nature of his particular job. Training in these subjects seems to me comparable to training in the specific techniques of communication, power, or traction. The student should have some appreciation of the problems involved, but beyond that can scarcely spare the time, in a four-year course, to learn much about these techniques.

In the Bell System Companies not more than a fifth of the engineers are working on the technical problems of design and development of apparatus and equipment. This is true in spite of the fact that the telephone system depends on advanced and complicated techniques to a high degree. It is true because the results of their work have general application, and are made available for the repeated use of other engineers.

By far the majority of engineers of the Bell System are engaged with operating Telephone Companies. Many engineers are in operating jobs with responsibilities for running the business. Although our business is highly technical in nature, their direct problems are largely of a business character.

I do not propose to discuss specifically the training of men for these jobs, but rather the training of men for engineering work. This is the type of work which a large proportion of recent engineering graduates in our Companies are doing. What I have to suggest, however, will help these men to be better prepared either for engineering jobs or for other types of operating jobs.

The engineering graduate who enters our employ, if he hasn't had previous experience, frequently finds that the engineering work covers a broader range of problems than he had imagined. Much of this work is of a type which might be called project engineering. It covers the whole wide gamut of problems involved, for example, in the extension of telephone plant. It includes estimates of the amount and distribution of future telephone service, and studies of the most economical design, amount, location, and timing of additions to the telephone plant so that with these additions the plant will take care of future service demands. It involves the selection and acquisition of land and rights of way, erecting buildings designed to meet the special technical needs of telephone service, designing overhead and underground structures for cables. It involves designing complicated electrical systems consisting of combinations of equipment and cables or other media of transmission, particularly radio. It involves coordinating these with the existing telephone plant. And as a background for all of this, it involves engineering planning, both long-term and short-term, to point the direction of development and establish the ground rules for specific projects.

While my description is in terms of the work of the engineers of the Telephone Companies, I think the work of a large proportion of the engineers in other utilities and in many other industries is similarly broad in scope.

Now, of course, the engineer handling these types of work, in an electrical industry, must understand the basic laws of electricity and magnetism and of other branches of physics. However, there are a lot of other techniques of the engineer with which he must also be familiar.

These are indicated or suggested in the excellent 1940 Report of the Committee on Aims and Scope of Engineering Cur-

ricula of this society. However, my discussions with recent graduates and review of current catalogues of engineering colleges indicate that in many colleges some or all of the important subjects are not adequately treated.

Engineering Economy

Of first importance among these underemphasized techniques I would place those involved in studies of engineering economy. The need for this is emphasized in the 1940 report. Nevertheless, three-quarters of my young associates didn't receive in college adequate training in this subject and half of them had no training whatever. A study of current catalogues indicates that much the same might be said of the 1950 graduates.

Engineering economy involves comparisons of the costs of different ways of doing a thing, and also comparisons of the cost of a project with its value. Comparisons of these types are as basic a tool to the engineers as Ohms law.

Also, engineering economy is not a simple subject, but one which is fairly complicated and technical. It involves comparing dollars spent this year with dollars to be spent ten years hence, both for capital investment and for operating expense. It involves integrating over a period of years the economic effects of alternatives which never become identical and making allowance for that lack of identity. It involves the immediate effects as shown on the books of the Company and the long-term effects over a period of years. It involves the distinction between incremental costs and a full allocation of total costs and an accurate realization of the proper use and limitations of each of these figures. It involves estimates of revenues as well as of investment and expense and of probable net return. It involves the realization of the degree of reliability and unreliability of such estimates, how to make the results as reliable as possible and how to avoid drawing false conclusions.

Except for a relatively small proportion of engineers who are engaged in research or highly technical development work, economic studies are a daily professional tool, used not occasionally but constantly in each step of the engineer's work. I have seen more inaccurate work done in this part of the engineer's job than in the parts requiring application of the laws of physics. Mistakes in this part of the engineer's work are just as serious as any other mistakes. I don't think an engineering course is in balance unless the men are thoroughly grounded in this subject.

Elementary Statistics

The next professional tool which I wish to mention might be called elementary statistics. Many men have had little or no training in methods of determining the precision of the results of measurement or computations. Such training is important not only in avoiding unproductive work but in developing a point of view. If a table of figures is shown to three or four digits when one digit is all that is significant, conclusions may be drawn from numerical differences which exist only because of the slight precision of figures.

Sampling is becoming increasingly important in engineering work. A similar background in elementary statistics is necessary for economical and accurate sampling.

It seems to me this subject constitutes an engineering tool of sufficient general importance to warrant its inclusion in engineering courses.

Engineering Reports

Another important tool of the engineer which I wish to mention is the written report. Nearly all of my young associates believe they would have benefited by more training in college in this subject. While most of them had training in written English, this training was only in varying degrees related to the kind of writing that they must do in their professional work. Also the training usually seemed to them inadequate in amount.

The art of writing satisfactory reports

has more to it than English composition. May I suggest that as a part of this training the student should be drilled in the general principle that a report, to be satisfactory, must be specifically designed to meet the needs of its audience. This means that a report by the young engineer, intended for his boss or some one higher up in the organization, is often in the best form if it consists only of a table of figures or a chart with a few notes at the bottom. When more text is necessary, the engineer should avoid the "detective-story" type of report—one which must be read all the way through to learn the answer. If these and similar ideas of how to make the most satisfactory report under various conditions can be taught the engineering students, it will help them to make early progress after graduation.

Human Relations

I have already discussed the importance of what I have called character in determining how the engineer gets along with other people. However, there is a technique of human relations which is very helpful to the young engineer who knows it. Some of the engineering colleges now have good courses in this subject but in my observation they are relatively few. Such a course should help the engineer more quickly and effectively to handle a variety of ticklish situations than he will if it is left to his own good judgment and experience to work them out. I think this subject may be classed with the others I have mentioned as one of the important professional tools with which the young engineer should be equipped.

Engineering Planning

The final subject on which I wish to comment is engineering planning. The young engineer as he comes into industry generally has very little conception of what is involved in carrying out the broad range of engineering studies of this type.

The term "engineering planning," as I am using it, includes those basic studies, both long-term and short-term, which form the background for major decisions and which constitute a frame of reference for carrying out specific engineering projects. Some engineering studies of this nature involve large scale fundamental plans which will determine a course of action and guide the engineering and other activities of the organization over a long period. Much engineering planning deals with shorter term problems or perhaps simply with the various major features of a project which must be coordinated in a complex engineering job.

Engineering planning thus defined is an advanced subject. It involves a high development of ability in constructive thinking and may be considered one of the highest forms of engineering activity. Admittedly competence in this kind of work is largely to be acquired in the school of experience. However, such work forms the background for the specific jobs given to the young engineer. If he is to become a leader he should early learn to think in terms of engineering planning. This will help him to make contributions to the underlying plans which guide his work as his increase in competence makes this possible. I believe, therefore, it is important to the young engineer to know from the beginning that there is such a type of work, to understand its important principles and to appreciate its uses and its limitations.

This is not the occasion to develop in detail a discussion of engineering planning. I want to point out, however, that there are certain basic techniques of engineering planning which can be taught.

In many respects engineering planning may be considered to be an exercise in applied logic. It involves comparisons between dissimilar things and evaluating the differences in relation to the ends to be achieved. It must be inclusive—to be sure that all useful alternatives are studied, no alternative should be entirely overlooked. It involves a critical examination of all assumptions. Those which have relatively unimportant effects on

the conclusions may be treated lightly, those which are crucial must be considered with great care.

There is a wide variety of engineering plans adapted to different. purposes Some are basic plans which point a direction. Some describe a future condition toward which to work. Some establish a program, that is, the specific steps by which advance is made from the present condition toward a future condition, and the timing of these steps. A planning project often involves all three of these types of plan in varying degrees. The engineer must determine the kind and scope of planning most useful for a given situation.

What can the engineering school do to give young men a start in this advanced subject? Let me venture a few suggestions for your consideration.

First of all, possibly more planning can be made a part of the work now given. This is done, for example, in some laboratories where the student is not told what to do but is required before he enters the laboratory to plan the project in detail, describe its aims, its methods and the apparatus to be used, and to receive approval of this plan.

Lectures by engineers in industry might be helpful. Such lectures would describe important planning projects in their own work and how these projects are carried out. It seems to me, however, the faculty would need to give a great deal of guidance to the outside lecturers so that what they say will be directed toward engineering planning and properly coordinated with the curriculum. Such lectures might be supplemented by others dealing directly with the principles and techniques of planning work.

A further possible step might be to add to the curriculum planning projects designed to train the student in the principles of planning, building upon the training of the various technical courses. Such projects, limited perhaps to engineering economy, are described in the paper presented by Professor Bell this morning in the session on Engineering Economy.

Where a thesis is required, this might be made more clearly a planning project. Possibly one reason why theses are not more popular is that in the past they have often required the student to spend large amounts of time in repetitious work, obtaining data or making computations. This in turn has limited the scope of planning work which could be covered. If it is possible to so organize the project that the student is relieved of repetitious work, and the thesis is made primarily a planning project, it would become, I believe, one of the most valuable parts of his college training.

Conclusion

This, gentlemen, concludes the specific suggestions which I should like to leave with you.

In brief, I have emphasized the importance of character, namely of the development of those characteristics which help a man in his relations with other people. The engineering college needs to be of all possible help to the student in this matter.

As to training in the techniques used by the engineer, I have expressed the view that more attention needs to be given to certain important professional tools outside the realm of physics. I have mentioned engineering economy, elementary statistics, engineering reports, the techniques of human relations, and the art of engineering planning. I believe it would be advantageous to give more work along these lines at the cost of some further reduction in the amount of training the student is given in specialized techniques. These suggestions seem to me to be in line with the 1940 recommendations of the Committee on Aims and Scope of Engineering Curricula.

In closing, let me say a word of tribute to the work of the engineering colleges. I am very much impressed with the high qualifications of recent engineering graduates. My admiration for your product

is enhanced by some awareness of the extreme difficulties of your task. You have a fixed length of time in which to work and a more or less fixed level of understanding on the part of your input. But with the rapidly expanding volume of engineering technique, you are supposed to raise the output to ever higher and higher levels. Before such a problem I can only say: I salute you for what you have done and wish you the best of luck for the future.

In Memoriam

ROBERT ERNEST DOHERTY

Dr. Robert Ernest Doherty was born January 22, 1885 in Clay City, Illinois and died October 19, 1950.

Before entering the University of Illinois, where he received a Bachelor of Science degree in 1909, Dr. Doherty worked two years as telegraph operator for the Baltimore and Ohio Railroad. This and earlier experience with electricity steered him toward electrical engineering. He received the Master of Science degree from Union College in 1920 while working with Dr. Charles P. Steinmetz at the General Electric Company.

In 1931 Dr. Doherty went to Yale University as Professor and Chairman of Electrical Engineering and in 1933 he was appointed Dean of the Yale School of Engineering, a post which he held until 1936 when he was elected President of Carnegie Institute of Technology. Dr. Doherty held this office until his retirement July 1, 1950. His success at Carnegie is summed up in the following citation adopted unanimously April 25, 1950 by the Carnegie Board of Trustees which said in part:

"When Robert Ernest Doherty came from New Haven to Pittsburgh in 1936 to assume the presidency of Carnegie Institute of Technology he brought with him two gifts that were destined to raise Carnegie Tech from its then status of a comparatively unknown conventional engineering school of average standing to its present recognized position of leadership among institutions devoted to engineering and technical education.

"The first of these two gifts was a vision; the second, rare qualities of sound common sense, inherent sensitive kindliness, superlative leadership and dynamic driving power. . . ."

Dr. Doherty played an active role in the educational programs of the professional engineering societies. In 1943–44 he served as President of the Society for the Promotion of Engineering Education (now the American Society for Engineering Education). He served on many committees of the Society, chief of which were the Investigation of Engineering Education, Aims and Scope of Engineering Education, and Revision of the Constitution.

In 1938–40 Dr. Doherty was Vice-Chairman of the Engineers Council for Professional Development, and Chairman in 1941–43. He also took an active part in the Engineers Joint Council.

Dr. Doherty played an important role in the civic life of Pittsburgh. In 1943 he proposed organization of the Allegheny Conference on Community Development and served as Chairman of the Conference from 1943 to 1946. In 1943, the Junior Chamber of Commerce of Pittsburgh presented him with its "Man of the Year" award.

An authority on electrical machinery and a pioneer in professional engineering education, Dr. Doherty received in 1937 the American Institute of Electrical Engineers Lamme award for "his encouragement of young men to aspire to excellence in electrical engineering"; and in 1946 the American Society for Engineering Education presented him the Lamme award for "noteworthy achievement in engineering education."

Values Inherent in Engineering

By J. R. VAN PELT
Battelle Memorial Institute, Columbus, Ohio

For many years we have sought practical ways to give the engineer a better background in social and humanistic studies. The results thus far have been good, but not good enough. Courses in the social studies and the humanities, in spite of careful planning and good leadership, have often seemed bafflingly ineffective with engineering students. Training in English, for example, has been stepped up, but employers still complain that many recent graduates cannot write or speak acceptably. Similarly, instruction in history has received added attention, but men are still being graduated who neither know nor care to know the background of the social institutions with which they must deal. To them, there is no point in Patrick Henry's famous remark before the Virginia Convention, "I know of no way of judging the future but by the past." The social-humanistic stem has been grafted onto the scientific-technical trunk, but it has not borne enough good fruit. It has flourished on the student's tree of knowledge just long enough to pass inspection; then it has withered away from lack of nutriment. The quality of the social-humanistic stem may have been fairly satisfactory, but the grafting job was not as good as we had hoped. Because a better job of grafting is needed, the program committee has arranged this three-day symposium to find out, if possible, how to make better grafts; or, in more customary educational language, how to integrate the teaching of social-humanistic studies with the teaching of science and engineering.

As a starting point, the program committee has suggested that we explore the so-called "values" that are inherent respectively in engineering, in the humanities, and in the social studies. My assignment is to discuss the values inherent in engineering. I propose, therefore, to outline those qualities that are developed in a typical student by his contact with scientific and technical training.

You will note that I shall not discuss the engineer as a whole man, nor enumerate any incidental benefits that he may derive from technical training. These are important, but my assignment is more limited; namely, to isolate, from the many values that technical courses may sometimes offer, those fewer values that they must always produce if taught with reasonable skill. After reviewing these items on the credit side of the ledger, I shall mention, by way of contrast, some debits —that is, some desirable qualities that technical instruction does not necessarily produce. And I shall close with a comment on what all this means to the teacher or administrator who wants to produce better engineers and better citizens.

Definitive Characteristics of the Engineer

Now, engineering is essentially a problem-solving occupation. That fact colors the thinking of every engineer. For the research engineer, the problems are to discover and apply natural law. The design engineer solves problems in the

* Opening paper in a symposium on the Integration of Engineering and Basic Science courses with Humanistic and Social Studies, presented at Seattle, Washington, June 23, 1950, under the auspices of the Division of Social and Humanistic Studies, ASEE.

economic use of materials. The engineer in plant operation solves problems in quality control, obsolescence, raw material supply, and trouble-shooting of all kinds. The construction engineer faces complex problems in logistics and in adapting plans and specifications to the unforeseen exigencies of the field. Engineers solve all these problems by rigorous calculation, by past experience, or by plain common sense, depending on the circumstances. But the main point is, the engineer's life is one long series of problems to be solved, and his success depends on promptly delivering good, workable answers. This problem-solving attitude is perhaps the most characteristic feature of engineers as a group.

Engineers, of course, are not the only problem-solvers. The merchant solves problems in business forecasting and marketing. The novelist has problems in psychology, the musician and sculptor in aesthetics, the historian in weighing the credibility of witnesses and in reading between the lines to understand the events and cultures of the past. Perhaps all human enterprises could be regarded broadly as problems to be solved. But the engineer's problems are, on the whole, more sharply defined, and their solution rests on more clean-cut data and principles.

The definiteness of the engineer's data gives him a strongly factual approach. His technical training shows him that the facts of nature are ascertainable and measurable. He is, therefore, skeptical of unsupported assertions, such as this one. He looks for evidence, not authority.

Furthermore, the engineer believes that natural law is dependable. He knows that if a certain set of engineering data and conditions leads to a given conclusion today in Seattle, the same data and conditions must surely lead to the same result at any time, anywhere. Experience supports his conviction, and gives him a characteristic reliance on logic—the formalized logic of mathematics. The clergyman may solve his problems on a basis of faith; the salesman, by intuition; the trial lawyer, by persuasiveness; the politician, by influence; the artist, by emotion. In comparison with these, the engineer seems to be a factual, literal-minded, unemotional fellow, at least in his technical work.

Since technical courses deal with cold facts and immutable laws, it is natural that the engineer's attitude should be impersonal. It is often said that engineering involves four elements—materials, forces, money, and men. The student ought to pay as much attention to the study of men as to any of the other three; but in the heavy task of mastering the first two, technical courses can allow little time for the cost factor, and still less for the human element.

Good engineering teachers do what they can to remedy this situation. One of the best of my own teachers, a mining engineer, often posed problems in the psychology of dealing with people, ranging from a disgruntled mucker with family troubles to the company president on his monthly inspection trip. But the fact remains that most of a technical course must be devoted to impersonal problems connected with the materials and the forces of nature.

The engineer deals with numerical quantities rather than ill-defined qualities. It would be useless for him to state that a certain bridge is "strong"; his job is to find out how many tons it can safely support under given conditions of loading. To him, numerical distinctions are much more meaningful than the hazy qualitative comparisons that are common in everyday speech. That accounts for the engineer's habit, so disconcerting to the layman, of talking in numbers and equations and mathematical symbols.

The engineer likes to use numbers, but he does not always insist that the numbers must be highly precise. He knows that precision takes time and costs money. He may order a mechanical part finished to a tolerance of a tenth of a thousandth on two surfaces but rough-machined elsewhere. He will solve many problems with a slide rule that cannot be read beyond

three significant figures; but when greater precision is worth while, he will use it.

The engineering student tends, also, to be utilitarian. He is not interested in knowledge for its own sake. Technical courses appeal to him because he expects to put what he learns to direct use. He approves of basic science courses in direct proportion to their apparent relationship to engineering. He tolerates social-humanistic courses because he can't graduate without them, or because someone has convinced him that they will be useful to him. He is impatient with any suggestion of dilettantism. Because no one has ever discussed with him the meaning of culture, he is inclined to confuse culture with dilettantism and a sort of revolting effeminacy. And unfortunately some so-called cultural courses are taught in such a way as to confirm his impression. No wonder he prefers to be strictly utilitarian!

Because the engineer is utilitarian, he is interested in results, not appearances; in meanings, not words; in realities, not shams. He is inclined, therefore, to ignore the non-essential niceties of life—until, perhaps, he meets a girl to whom such things matter.

It is only a short step from the engineer's utilitarian outlook to his empiricism. By empiricism I mean reliance on experience rather than on theory. The basic scientist typically asks "why"; the engineer asks "how."

In engineering practice, this empirical attitude is often helpful. It promotes economical and safe design. It restrains the engineer from risking the soundness of an expensive structure or process by using untested innovations based only on theory. Because of this conservative empiricism, serious failures in engineering design are extremely rare, and the engineering profession has established an enviable record of sound and reliable service to the public.

In research, on the other hand, where the purpose is to find new techniques or materials or to develop a new product, dependence on past practice may prove to be a weakness. The purpose of research is to explore new, untried possibilities. Research thrives on unconventional ideas, disciplined of course by a knowledge of basic principles.

Engineers trained in Europe appear, on the whole, to be less empirical, more theoretical, than Americans. No doubt this explains the frequently noted difference between European and American engineering, namely, that Europe leads in making technical innovations, while America is superior in organizing efficient production.

Perhaps it is fair to say that engineering instruction develops a sense of money values. At least it should. Costs are, of course, a highly important aspect of engineering. It would be interesting to find out how a department of economics might best cooperate with engineering departments to develop financial understanding.

Empiricism and Ingenuity

I wish I could add ingenuity to the list of values inherent in engineering. After all, the words "ingenuity" and "engineer" are derived from a common root. The fact, however, is that so-called practical, descriptive courses tend to discourage ingenuity. They leave the impression that all basic problems have been solved. It is only when engineering courses probe deeply into basic causes and explore the frontiers that they encourage ingenuity. Fortunately, courses taught in this way are steadily increasing in number.

It has been reported that years ago, at California Institute of Technology, Dr. Robert A. Millikan and his associates recognized the need of sparking the students' imagination, and they started an extra-curricular activity known as the "Wild-Eyed Idea Club." At the meetings of this club, technical ideas were debated far into the night. The only proviso in submitting an idea for discussion was that it must be new and unconventional. I don't know how long this club flourished, nor how many startling developments were born at its meetings, but it is safe to say that because of the discussions, its members

are today more ingenious, more versatile. We need more Wild-Eyed Idea Clubs.

The importance of ingenuity is recognized in industry fully as well as in engineering schools. In 1942 and 1943 the American Society of Mechanical Engineers presented a stimulating series of papers on the general subject of "Creative Engineering." In one of these papers, Charles F. Kettering said that if a person had a scientific education, he was only about half as likely to make an invention as if he had not had that specialized training. "As a result," said Kettering, "I have arrived at a definition of what an inventor is. An inventor is simply a fellow who doesn't take his education too seriously." [1] And he went on to explain, by cogent examples, how hard it is to "stick by" a new idea when all the books say it won't work.

Ingenuity, or what has been called "imagineering," is not by any means unknown in technical courses. We have seen that it depends in part on subject matter; that it is encouraged by courses that deal with basic causes, and discouraged by those that are of the descriptive, memory type. It depends even more, however, on the personality and attitude of the instructor. Perhaps in tomorrow's session someone will suggest ways in which ingenuity can be encouraged, either in the technical departments, or in social and humanistic courses, or by a joint effort of these two groups.

Let me suggest one more trait, and the list will be closed. The engineer gets things done. There is a concreteness and an urgency about engineering problems that encourage effort and accomplishment. The engineer works best when there is a specific problem to be solved in a reasonable but limited time. He loses interest in a program of hazy outline, flexible objective, and unknown completion date. In this respect he differs from students of a more relaxed, philosophical type.

[1] Kettering, Charles F., "How Can We Develop Inventors?" *Creative Engineering,* ASME, July, 1944, p. 13.

You will note, of course, that this analysis does not purport to be a complete picture of an engineer. It includes only those traits that appear to grow directly out of technical training. Yet even in its incompleteness, the sketch reveals characteristics of which anyone might well be proud. It shows that in solving a problem the engineer usually starts with a solid foundation of definite, measurable facts; that on that base he builds logically, with integrity, and with an eye to overall economy and utility. It shows that he respects experience; but at the same time, given good basic training, he has the ingenuity to make innovations. And it pictures the engineer as a man of action and accomplishment. Probably most of the amazing success of modern engineering can be credited to these inherent attributes of the profession.

Rounding Out of the Engineer

It is in no sense a reflection on technical training to say that, great as its values are, they do not provide in themselves a complete foundation for a well-rounded personality. Let us turn, therefore, to the other side of the picture. What values are conspicuously missing from technical courses? These values must be gained, either in the social and humanistic courses, or entirely outside the classroom.

First, technical courses cannot provide systematic treatment of the subject of individual and mass psychology. Yet an understanding of human motives and reactions is essential for an engineer. Engineering innovations, notably those that involve employment changes of any kind, are often a source of misunderstanding among employees—misunderstanding that could have been avoided if the program developed by the engineering department had taken the ambitions and fears of the employees and community into consideration.

Second, technical courses give the engineer no contact, or at best only fragmentary contact, with the social, economic, and political environment surrounding his professional work and his private life.

Engineering practice cannot be separated from its human environment; hence systematic study of this environment is important for the engineer. Industrial housing, safety programs, air and water pollution, industrial hygiene, recreational facilities, plant layout—these and many other subjects require both engineering skill and an appreciation of their implications in terms of human welfare.

Again, technical training provides little or no historical background for the engineer's judgments. As Henry Ford once said in an unguarded moment, "History is bunk"—when it consists, that is, of unrelated dates and similar scraps of miscellaneous information. That, unfortunately, is the kind of history still being taught in many schools. But history is far from bunk when it records the ideas that have stirred men and guided their action; or when it reveals the ways in which science has so profoundly changed the world. History, properly taught, can be of great value to the engineer, and he cannot get much of it from engineering courses.

In the field of the arts, ranging from architecture to music, engineering courses cannot help much. They give the engineer little or no basis either for personal enjoyment of the arts or for informed judgments on the aesthetics of engineering design.

In the realm of communication of ideas, the engineer needs three languages--the language of mathematics, the language of graphics, and the language of words. The first two are covered in his technical courses, but these courses do little to teach the use of the written and spoken language—the most powerful, most flexible, and most widely understood means of communication.

In the field of logic, technical courses give an admirable training in the rather stereotyped processes of solving engineering problems. They tend, however, to leave one with the impression that the laboratory is the only avenue to truth, that mathematics is the only reliable form of reasoning. They cannot be expected to provide contact with truth arrived at by other means—for example, through aesthetics, intuition, faith, or emotion. Indeed, many engineering students frown upon these in public as though they were something to be ashamed of, even though they utilize them on occasion in private.

Finally, engineering courses are not sufficient in themselves to lead to a well-rounded personal philosophy. It is true that good engineering teachers teach professional ethics. They also inculcate integrity of a high order in dealing with natural law. This integrity, if carried over to other aspects of life, would give the engineer some foundation for his personal philosophy. The existence of this carry-over, however, has not been established; and in any case, a man's working philosophy should rest on a greater knowledge of man than engineering courses can convey.

Humanities Should Capitalize on the Engineer's Characteristics

Let me summarize. I have named ten values that are present in technical training, and seven that are absent, or at least not inherent in strictly technical instruction. I have said that technical training tends to make the student a productive, cost-conscious, potentially ingenious solver of problems, whose intellectual processes are factual, mathematically logical, impersonal, quantitative, utilitarian, and empirical. I have said that technical training short-changes him on knowledge of psychology, history, the social environment, aesthetics, language, and modes of reasoning, and cannot by itself give him the basis for a well-rounded working philosophy.

Such, then, is the environment of the engineering student so far as it is controlled by technical instruction. The teacher of the humanities or of the social studies cannot afford to ignore this environment; he must live with it and adapt himself to it. How can he do this?

For one thing, he can put most of the characteristics of the engineer to good use. For example, in his own courses he

can utilize the engineer's propensity for problem-solving. The social studies and some of the humanities lend themselves well to the problem or case method. Since the engineering student seems to prefer such an approach, why not use it whenever you can? The result will be greater student interest and comprehension.

Since the engineer is utilitarian, his teachers will accomplish most if they work on the principle that all education is "education for use." Even the arts are included in an engineer's education because they will be used—sometimes directly in professional work, sometimes in leading a fuller, more useful, more satisfying life. The adoption of this principle has far-reaching effects, both on the selection of subject-matter and on the mode of presentation to engineering students.

In the same spirit, the teacher of social and humanistic courses can utilize the engineer's interest in factual data and his distrust of authoritarian statements. He can help the student to build an analytical, discriminating attitude toward what he hears and reads. In a few engineering schools this has taken the form of "propaganda analysis," in which pronouncements about current economic and social issues are scrutinized in the light of the fundamental data, much as an engineering problem would be approached.

In the social studies especially, there are many opportunities to use concrete data rather than vague generalities. Consider, for example, the social and economic effects of substandard housing. Instead of reading the ex-parte conclusions of some specialist on this subject, a class might study a case history or two. Then they might solve a clearly defined problem in industrial housing, such as the planning of a new mining town. They would start with all the essential data about the size, expected life, and finances of the mining company, the number and type of personnel to be housed, the town site, the facilities in nearby communities, and other environmental factors. Each student would solve the problem in his own way, and would defend his solution in terms of costs versus values. The class discussions would lead finally to a statement of the general principles that should govern company policy on matters of housing. Because the solution began with hard facts, it should lead to a workable balance between idealism and practical economic necessity.

It may be objected that there is not enough time for this analytical approach. This opens a basic question of educational psychology. Certainly a general survey of the social studies, offering uniform coverage of the whole subject, could not possibly go into such detail on industrial housing. It may well be argued, however, that intimate probing of a few problems of vital interest to engineers is more valuable than systematic but superficial skimming of a whole field. Students get excited about such problems and study them intensively; as a result, they not only solve the special problem assigned, but also build a surprisingly broad knowledge of the whole related field.

It is evident from these examples that the humanistic-social departments can make good use of the attitudes that the student brings from his technical interests. They are good as far as they go. But sooner or later the teacher of the humanities and the social studies must go beyond the engineering attitudes and create new ones. He can show the student that there are good, utilitarian reasons why he should develop some new attitudes to accompany, not to replace, those derived from technical instruction.

For example, in economics, the facts about the flow of wealth in a competitive society may prove more elusive, certainly less precise, than the facts about the flow of air around an airfoil. The teacher of economics should openly recognize the difference. He should help the student to see that decisions must be made even though both the data and the method of treatment of the data are indefinite. In short, he should help the student to develop his nonmathematical judgment, his sense of values, his ability to weigh intangibles.

In all matters of human relations, it is necessary to reach beyond the engineer's tendency to be impersonal. The teacher should show the essential difference between dealing with inanimate nature and with people.

President Keith Glennan of Case Institute, in a recent address [2] before the Ohio Section of this Society, presented the case for better training of engineers in all aspects of human relations. He closed with these words: "Instruction in human relations is today's frontier in engineering education. Its exploration requires the courage and far vision of the pioneer." President Glennan said, in effect, that this is the golden opportunity of the members of this Division—an opportunity to serve in the most exciting spot in the whole field of engineer training. What will be done about it? What effort will be made by faculty members in social and humanistic fields to adapt themselves to the exigencies of teaching engineers? Will they insist that humanistic and social courses for engineers must be precisely the same as for everyone else, or will they recognize the existence of a special situation? Will they take the trouble—perhaps a great deal of trouble—to familiarize themselves with the engineers' interests, background, language, and psychology? Do departmental fences mean a good deal to them, or are they willing to break down these barriers and build interdepartmental courses whose purpose is well-rounded development of the whole man? Are they willing to do the research and suffer the hardships of pioneering that go with such new ventures? And perhaps the most pregnant question of all is this: are the administrative officers of engineering schools willing and financially able to support such a program? The answers to these questions will have much to do with America's position in the industrial world in the generation ahead.

[2] Glennan, T. Keith, "Human Relations in Engineering Education." *The Journal of Engineering Education*, 40: 416, April, 1950.

College Notes

Election of four educational institutions to active membership in the **Engineering College Research Council** of the American Society for Engineering Education was announced last night by Dr. Gerald A. Rosselot, director of the Georgia Tech Engineering Experiment Station and Chairman of the Council. The four are: **California Institute of Technology; Dartmouth College** (Thayer School of Engineering); **Montana State College;** and **University of Toledo.** Extensive activity in engineering research supplementing an effective program of undergraduate engineering education is required for election to the Research Council, according to Dr. Rosselot. These elections bring to 88 the number of institutions active in the organization, which represents the leading educational and research centers in the United States.

The Seven Deadly Sins of Teaching

By WILLIAM P. GODFREY
Department of English, University of Detroit

Whenever, during more than twenty years of teaching English in college, I have emerged from a classroom with a sense of defeat (it has happened too often for complacent retrospection), it was usually because I had been guilty of one or more of the following sins of commission or omission: 1. Failure to Prepare. 2. Sarcasm. 3. Dullness. 4. Garrulity. 5. Tardiness. 6. Digression. 7. Belligerence. My conscience is not soothed by the reflection that all of these vices, with the possible exception of garrulity, are often indulged in by the undergraduates both in the classroom and outside (Garrulity is more often reserved for the bull session). It is also small consolation to remember that most of these social sins are not the exclusive prerogative of the teaching profession. It is likely that their effects are more deadly to the teaching relationship than to more casual and less confining social relationships. Digression, for example, may lend the charm of variety and spontaneity to ordinary conversation; but the class grind feels that a little digression goes a long way.

With these preliminaries disposed of, I should like to make a few comments on each of these pedagogical failings.

Failure to Prepare. I suppose that many of us, after we have taught the same material for a number of years, are tempted to omit all but the most cursory inspection of our notes before meeting our classes. Whenever I have yielded to this temptation, I feel that the class suffered, i.e., more than usual. I list this vice first because like the love of lucre it is radical: it is often the cause of other evils. For example, lack of preparation or last-minute "preparation" frequently accounts for professorial tardiness. Inadequate preparation is a natural prelude to digression. Careless preparation may lead to a fear of losing "face." This in turn may induce an attack of bluffing or belligerence. The experienced teacher may betray poor preparation by his mechanical reproduction of well worn subject matter; in other words, the vice of dullness; the inexperienced teacher may betray it in his simple, unvarnished ignorance. On the other hand, adequate preparation not only may help to suggest fresh methods of presentation, but may give a deeper insight into the principles of the material to be covered. One phase of preparation often overlooked is the relation of these principles to the objectives of the course. Keeping this relation in mind adds greatly to the effectiveness of the teaching, for it tends to eliminate waste motion and to concentrate attention on the essentials.

Sarcasm. Provided it is not directed against anyone in the classroom, sarcasm is a legitimate weapon. Used against a member of the class, however, it is not only uncharitable; it sets up a block to the transfer of knowledge from the sarcastic teacher to the student whose ego has been lacerated. In the interests of justice we might do well to reflect that although Joe College is a bit obtuse at times, we teachers are not always models of perspicacity. Even if we happen to be right in our dim view of an undergraduate, a proper respect for the human persons exposed to our care should help to overcome the temptation to make that view known. It might also help to re-

call what Goethe said about ridicule: "To a man of thought almost nothing is ridiculous." If the witty teacher must have a target for his witticisms, what better target could he find than his own frequent dullness?

Dullness. The teacher does not live who scintillates unceasingly in the classroom; although if we are to believe some of the undergraduate teacher-rating polls, some of us could easily qualify as ever reliable bores. We may discount some of this as due to undergraduate ebullience, but all of us have our soporific moments. I have already touched on a possible cause of dullness in teaching: deficient preparation; another cause, the dull personality, I trust, is outside the scope of these remarks. But this much can safely be said: mastery of the subject is not an infallible guarantee against lackluster teaching; neither is enthusiasm. Yet without mastery of the subject and enthusiasm for it, the teacher, apparently miscast in the role of educator, would have to be Fred Allen to keep the class awake. Somewhere between the two extremes of mere entertainer and mere dull 'uns most of us ply our trade, more or less unconsciously tempering academic showmanship with a saving alloy of the jejune. Sometimes it is the fault of the professorial monotone. Undergraduates who rated me recently berated me for reading my lecture notes in a manner that was more conducive to slumber than to learning. The remedy is clear. Sometimes it is the fault of the professorial lack of humor. Here the remedy is not so clear. Can a sense of humor be acquired?

Garrulity. Delight in hearing one's own voice is not the exclusive prerogative of us teachers. It is just that our opportunities are more numerous. To resist the urge to pontificate or at least to expatiate requires more self abnegation than most of us are willing to develop. One way I try to limit the volume of my own classroom verbiage is to remind myself that the process of education is not all absorption; there must be some expression or extraction. However, undergraduate discussion is a good deal like faculty discussion in one respect: there are always a few who want to do all the pontificating and expatiating. These garrulous people must be restrained in order that justice may be done to the more retiring members of the class. If this democratic procedure does not elicit some good student opinion on the subject under discussion, the teacher can always fall back on the soliloquy.

Tardiness. Just as there are accident-prone people, so there are teachers who are allergic to punctuality. I suspect that some of the former are some of the latter too. At any rate, the tardy teachers usually have an interesting explanation, which comes pantingly forth to those of the class who out of sheer devotion to the grade are still hanging about. Sporadic lateness is a minor vice, perhaps, but chronic unpunctuality like alcoholism is a disease. It shortchanges the undergraduates; it is the pedagogical equivalent of goldbricking and feather-bedding. It may be the offspring of sloth or lack of foresight, but it probably derives more often from last-minute preparation. Maybe Franklin was right in calling strict punctuality a "cheap virtue," but I doubt if many undergraduates would agree with him—at least with reference to the unpunctuality of the teacher. Their own is another matter.

Digression. Teachers being what they are and students being what they are, digression is inevitable. Frequently it is induced in the former by the latter; at all other times it is unconscious on both sides. Many undergraduates get to be masters of the diversionary tactic. The garrulous teacher is especially vulnerable, for the will to resist is feeble. Digression being inevitable, the only question is: how long is it to continue? That usually depends on the teacher. If he combines self-discipline with an insight into student duplicity, he will interpret correctly the flattering signs of attention; if he concludes that these signs are evidence of

recognition of his superior perspicacity or eloquence, the digression will last until the bell rings. It sometimes happens that these deviations reveal matter of more value to all concerned than the orthodox content of the course. More frequently, however, in such deviations the sharpshooters of the class are merely exploiting the follies or foibles of the unfortunate instructor. I feel that over the years I may have built up a measure of sales resistance, although I am fully aware of our professorial penchant for self-deception. At any rate I find it helpful to make a fairly careful distinction between the meat and the dessert of the course. Thus although English is looked upon by many as the light lunch of the engineering curriculum, I try to keep my serving from being all whipped cream.

Belligerence. In one sense this is the most deadly of the seven pedagogical vices. One reason is that it may stem from a deficiency of love for human beings. Failure to try to live up to the second greatest of the Commandments seems to argue an incompatibility for the noble profession of teaching. Again belligerence may be due to what Newman called the giant among the capital sins—pride; the educational manifestation is a sense of the global significance of one's own opinions. Belligerence may spring from the insecurity occasioned by ignorance. In these cases, the remedy seems clear enough though it may be difficult to apply. As if the teaching process did not have enough of the element of struggle in its very nature, the bellicose teacher looks upon every meeting with his class as a pitched battle wherein he matches his whole wit against the fractional wits of the class. His battle cry is, "Thou shalt not pass." It is sobering to reflect that teachers like this bear about the same relation to truth as do the editors of *Pravda* or *Izvestia.* Such pedagogues are not intent on developing the mind of the undergraduate; they are intent on maintaining the superiority of their own. No wonder that only parrots, yes men, and robots survive the ordeal of studying under these humorless creatures.

Most of us, including myself, are guilty of some of these vices some of the time, and some of us all of the time. It is not so much that we do not know what to do as that we need to be reminded. It is in the conviction that we all have room for improvement in the conduct of our classes that I have humbly offered these comments.

College Notes

The recently completed Alumni Scientific Laboratories Building at **Drexel Institute of Technology,** Philadelphia, was opened for inspection by guests of the Institute on December 12, 1950. The inspection, and reception in the new laboratories building, climaxed Drexel's annual observance of Founder's Day. This structure—the first of several contemplated under Drexel's Expansion Program—will more than double the space for engineering. The additional space is required for engineering because of the further development of the undergraduate curricula, addition of graduate studies leading to the Master of Science degree, and the addition of a program leading to the Bachelor of Science degree in the Evening School.

Professional Advancement of Engineering Teachers[1]

By HENRY H. ARMSBY
Vice President, ASEE
Specialist in Engineering Education, U. S. Office of Education

The young engineering teacher of today who aspires to be the professor, the dean, the college president of tomorrow must realize that his promotion, just as that of the young engineer in industry, will depend largely on the nature and extent of his professional growth. Furthermore, the teacher must show growth not only as an engineer, but also, of at least equal importance, in ability as a teacher. *This paper discusses some of the ways in* which the engineering teacher and his institution can promote such growth.

Professional Development in Industry

There is much need in industry for engineers to acquire a sound understanding, not merely of scientific principles and their practical applications, but also of the social, economic, and political implications of his work. This calls for a strengthening and expansion of post-graduate training both in colleges and in industry.

The general recognition of this need was exemplified by the deliberations of the Inter-Professions Conference on Education for Professional Responsibilities at Buck Hill Falls, Pennsylvania, in April 1947, and by the findings of the Engineers' Joint Council survey. It has been the subject of recent papers before the Engineers' Council for Professional Development and other organizations.

[1] Condensation of paper presented before Southwest Section, American Society for Engineering Education, April 15, 1949.

Professional Development in the Colleges

If engineers in industry need post-graduate training to insure their professional growth and development, what of the men who are to give them this training? The successful engineering teacher must be not only a good engineer, but also a leader of men who can instill in his students a spirit of scholarship and a desire to develop themselves professionally. This he can do only if his institution makes clear to him that he is expected to grow and to develop, and gives him opportunities to do so. The college should provide as many such opportunities as local circumstances permit, and encourage the young teacher in every way possible to take advantage of them. A few such opportunities are discussed below.

Orientation

The process of orienting a beginning teacher to his new work, of getting him off to a good start, is highly important. Industry has found that happy and well-satisfied employees produce more and better work than unhappy, disgruntled employees. The same conditions apply to college teachers. The new teacher should be given information about such practical things as finding a place to live and to eat, shopping, entertainment. medical services, extracurricular activities of the institution, the organization and administration of the teaching division in which he is to work, the functions of the various college or university officials,

institutional policies on insurance, retirement, tenure, salary, promotions, etc.

Graduate Work

Many industrial and governmental agencies are assisting their young engineers to secure graduate courses, in some cases conducted on the premises of the agency by a college for credit toward advanced degrees. It seems only proper that the colleges should give their young engineering teachers comparable opportunities.

Some colleges provide for sabbatical leave for this purpose, but in too many cases the financial obstacles are too great for worthy and capable young teachers to avail themselves of the privilege. Some colleges permit young instructors to do graduate work in the institution where they are employed, but too often the instructor has such a heavy schedule of teaching that he finds it impossible to take advantage of this theoretical opportunity. Much more could be done along this line than is being done, and the institutions would reap great benefits from enlarging the opportunities for their young instructors to take graduate courses.

Industrial Experience and Consulting Practice

The majority of engineering graduates find their employment in industry. The proper division of educational responsibility undoubtedly calls for the college to place its major emphasis on teaching fundamentals, leaving to industry the function of acquainting the young engineer with practical applications and specific operating procedures. However, the truly general fundamental principles which must be mastered in college are not increasing in number at nearly as fast a rate as are their industrial applications. The engineering teacher needs an acquaintance with industrial practices and methods, in order to keep his teaching in line with developments in industry, and to give it vitality. The engineering colleges should encourage their teachers, particularly the younger men, to gain industrial experience, through summer jobs or even through occasional leaves of absence for industrial employment.

It seems conceivable that there might be developed a program under which teachers and industrial engineers would from time to time change places with each other, forming roughly the equivalent of the "two-man team" plan used by colleges which operate on the cooperative basis. Recent Civil Service rulings make possible a sort of modification of this plan in the Naval Research Laboratories and the National Bureau of Standards, which have been given authority to offer temporary employment to faculty members, as well as to graduate and undergraduate students. It is to be presumed that other departments of the Federal Government can secure the same authority.

Industrial and research experience should be followed by consulting practice, which the young teacher might well start under the tutelage of an older staff member. He should be encouraged to branch out on his own just as soon as he is qualified, and his teaching schedule should permit him to do a reasonable amount of such work. However, his objective should be to improve his knowledge and broaden his interests, rather than merely to increase his income.

Industrial Conferences

Participation in programs similar to the Institutes of Management conducted by Southern Methodist University and the symposiums conducted by the Harvard Graduate School of Business Administration, and participation in the placement program of his institution, should be extremely valuable adjuncts to actual industrial experience, and should greatly help the young teacher to learn what industry looks for in young engineers.

Participation in Technical and Educational Societies

If the young teacher is to become a truly professional engineer, he must take

an active part in his own technical society. If he wishes to become qualified as an engineering teacher he should also take an active part in the affairs of ASEE. Nothing is quite so valuable to the young teacher as the inspiration he can secure by contacts with the leaders of his profession. His college should encourage him to be active in these societies, and should consider the amount and character of such activity in making promotions.

Research

The essence of good teaching, particularly on the college level, is the inculcation in the student of a desire to learn, which is the basic urge of the research worker. Students who learn for themselves things not covered in texts or lectures, who make what are to them new discoveries, are research workers. Their techniques may be simple, and their discoveries may have been anticipated by others, but their spirit is that of the scholar. Hence, the really successful teacher endows learning with the spirit of research. This he cannot do unless he has the research spirit himself. Therefore, research and teaching are closely interrelated, and training research workers should be one of the primary functions of the university. Competent scholars as faculty members, with actual experience in research, and with adequately financed research projects on which they and their students can work, are the only means whereby the university can fulfill that obligation.

A recent study conducted by Rensselaer Polytechnic Institute quotes a group of industrial executives as believing (a) that the demand for research scientists and engineering specialists will continue to increase during the next ten years, (b) that college laboratories should be used primarily for thorough grounding of students in basic principles but that modern equipment should be maintained and modern production methods illustrated in the laboratories or demonstrated in cooperation with industry, and (c) that industry and business should provide additional funds to help the colleges of engineering meet the growing demand for research scientists and engineering specialists.

All of this adds up to the fact that the young engineering teacher should be given opportunity to participate in research projects, at first under the guidance and supervision of older staff members, but with increasing responsibility given him as fast as he is able to take it. This, of course, implies that the teacher should not be given such a heavy teaching schedule that he has no time or energy for research. Research should be a definite part of his assignment from the beginning of his teaching days, so that he may quickly become imbued with the spirit of research. The studies of the ASEE Committee on Faculty Salaries indicate general agreement with this policy on the part of engineering college administrators.

On the other hand, it must not be overlooked that he is primarily a *teacher*, and that competence in research alone cannot take the place of inspirational teaching, which stimulates people to clearer thinking, greater endeavor, good citizenship, and human decency.

Development of the Young Teacher as an Educator

The charge is sometimes made that engineers are not interested in methods of teaching, and that they feel the entire emphasis of the training of an engineering teacher should be on subject matter rather than on methods of teaching. Teachers in grade schools and high schools must be trained in methods of teaching as well as in subject matter, but it seems to be normal procedure in engineering colleges to consider that an engineering graduate knows how to teach college students without any training in teaching methods.

Possibly a student of college age can absorb instruction from a poor teacher better than a grade school child can, although this is open to question. But

engineers, who pride themselves on their efficiency, might well apply the same basic idea to their teaching, and at least *try* to make their teaching as effective as possible. Certainly all would agree that the engineering teacher needs to know subject matter, needs to know *what* to teach, but surely some knowledge of effective methods of teaching and of the psychology of learning should help the engineering teacher to do his job better, and enable his students to learn more with less effort in a given length of time.

Methods of Improving College Teaching

The first "prerequisite" to any systematic efforts to improve college teaching is an administration which is keenly interested in such improvement, and which makes it clear to the young instructor that his advancement will depend more on his ability to develop into a good teacher, able to inspire his students and to educate them to think for themselves and to form their own opinions, than it will on the number of degrees he holds or on the number of square feet of published material he issues.

Many schools are holding lectures or seminar sessions on methods of teaching, and several have issued manuals on teaching, notable among which is the manual issued under the direction of Dean Norris of V.P.I. and endorsed by the Engineering College Administrative Council of ASEE.

The engineering teacher is seldom told by anybody whether or not he is doing a good job. There seems to be prevalent an unfortunate attitude that visits to a teacher's class are instrusions into his private business which should not be tolerated. The young teacher might receive valuable suggestions if he invited such visits by his dean or department head, more experienced teachers, practicing engineers, or staff members of the School of Education.

The teacher might even benefit from an occasional rating of himself as a teacher by his students, as for example by the use of the Remmers test or some similar instrument. Even if he feels that his students lack the necessary knowledge to rate teachers perfectly, he might get valuable tips from them as to his weak points and his strong ones.

Conversely, new teachers should have opportunities to sit in classes of those of their more experienced colleagues who have developed successful teaching methods, in order to observe at first hand their techniques and standards. However, since mere length of service as a teacher is not necessarily a guarantee of good teaching methods, care should be exercised in selecting the teachers he is to observe.

Conferences with others teaching the same courses, for discussion of teaching methods, testing devices, grading, and similar problems, should benefit all concerned, especially the new teacher. The summer schools sponsored by ASEE should be especially valuable in this connection, since they are supposed to place major emphasis upon improving the effectiveness of teaching.

Teachers can gain breadth of vision and experience by being assigned to a variety of subjects in different years. The change in subjects should not be too often, but often enough to keep the teacher from getting into a rut.

The practice of defining objectives of a course in terms of results which can be measured, and of applying suitable tests to measure them, is a device which holds promise of benefit to the new teacher. These tests may be developed by the instructor himself, or by others, and might well be identical tests given to several sections taught by different instructors.

A study of the grades given by the instructor, the weights which he gives to various aspects of the student's work, and the relation of the instructor's marks to those of other teachers, may yield information of value to the new teacher, as may the use of some of the self-rating scales for teachers which have been developed.

The Buck Hill Falls conference of 1947 spent considerable time discussing teaching methods. General agreement

was reached that the primary concern of professional education is the development of power to acquire knowledge and to learn from experience. It was also generally agreed that the student should be taught to use knowledge as a part of the process of acquiring it, which involves teaching a thorough understanding of fundamental knowledge, largely by means of the inductive process, that is, acquiring it from dealing with concrete material under the student's own steam. This includes (a) teaching the art of extending knowledge by having the student induce principles from what have been termed "instances," and (b) teaching the student to *use* fundamentals by the use of professional problems in which he does creative work.

Research studies to determine the relative effectiveness of different instructional procedures, as well as faculty institutes, seminars, and workshops devoted to problems of higher education are useful devices which might increase the effectiveness of teaching.

The Office of Education is undertaking a study of many proposed methods for improving college instruction. Colleges and graduate schools will be asked to indicate on a check list devices they are finding helpful, and to describe methods not included on the check list. Efforts will then be made to stimulate further development of some of the more promising devices, and to interest institutions or groups of institutions in the conduct of research projects such as comparative studies of the relative effectiveness of two or more proposed devices. Whether or not this study develops into some kind of a manual for college teaching, the mere carrying forward of the project should stimulate active interest in the improvement of college teaching. The engineering schools are in a position to make some worth-while contributions to this study.

The Ideal Teacher

Dean A. A. Potter of Purdue recently wrote a paper, "The Forgotten Man in Higher Education," which in my opinion should be "required reading" for engineering teachers. Dean Potter says that the teacher, who is the essential factor in the educational process, is the forgotten man; that too little attention is given to the improvement of the quality of teaching; that "Too few realize that the teacher may enlighten and strengthen, or he may poison and weaken the mind of the learner." He then proceeds to write what he calls the specifications for an effective teacher. I am inclined to believe that Dean Potter would agree with me that these specifications describe an ideal teacher, that no one teacher could be expected to exemplify all the characteristics which he outlines, but that any teacher can, by striving to reach the ideal he describes, make of himself a *good* teacher, one whose students will not be mere *people* crammed with facts, opinions, and phrases, but rather *individuals* who can *think* and *form their own opinions.*

Some of the characteristics of Dean Potter's ideal teacher are enthusiasm, humanity, fairness, tolerance, high ethical standards, cooperation, intellectual curiosity, ability to analyze and synthesize facts, good study habits, ability to express himself clearly and understandably, and above all his continual effort to improve his knowledge by advanced study, practice, travel, research, and contacts with leaders in his field. "The master teacher shuns intellectual ruts, as he realizes that a rut differs from a grave only in dimensions and outlets."

Dean Potter closed his article with the following paragraph: "Finally, it must be remembered that the compensation of the teacher is not represented by the salary he receives or by the academic rank he holds: much of his satisfaction comes from work well done in an atmosphere which is conducive to high ethical standards, human sensitiveness, and productive scholarship. He loves his work and derives satisfaction from the successes of his colleagues and students. The teacher is certainly fortunate in the awards and satisfactions of life which his calling affords him!"

The engineering profession has made great progress on the road toward efficient utilization of natural resources. If all engineering teachers could measure up to the ideals Dean Potter has set before them, the profession could advance still further, and in addition could greatly improve its use of human resources. It is my thesis that, while perhaps few of us can fully attain the ideal, we can all be greatly improved as engineering teachers if we and our institutions will work together in implementing at least a few of the procedures I have suggested for furthering the professional development of engineering teachers.

SELECTED BIBLIOGRAPHY

Some recent papers and books bearing in whole or in part on various phases of the subject.

BARLOW, H. W. "The Young Teacher—His Introduction to Engineering Teaching." Paper before Association of Land-Grant Colleges and Universities, Division of Engineering, November 1948. Mimeographed.

Clemson Agricultural College. "Faculty Handbook of Information." *Bulletin*, New Series, Vol. 23, September 1948.

DAVIES, CLARENCE E. "The Difficulties Young Men Contend With." *Journal of Engineering Education*, Vol. 39, January 1949, pp. 282–287.

Engineers Joint Council. "The Engineering Profession in Transition." Published by the Council, 33 West 39th Street, New York, N. Y. 1947.

HAMMOND, H. P. "Education for Professional Responsibility." *Journal of Engineering Education*, Vol. 39, November 1948. pp. 142–146.

HAMMOND, H. P. "The Young Engineer—His Professional Growth and Development." *Mechanical Engineering*, Vol. 71, January 1949. pp. 8–10.

HILSENRATH, JOSEPH. "Cooperation in Education Between Government Laboratories and Engineering Colleges." *Journal of Engineering Education*, Vol. 39, December 1948. pp. 203–212.

Inter-Professions Conference on Education for Professional Responsibility, at Buck Hill Falls, Pennsylvania, April 1948. "Education for Professional Responsibility—Report of the Proceeding of. . . ." *The Carnegie Press*, Carnegie Institute of Technology.

Contains brief bibliographies on professional education.

Navy Department, Office of Naval Research, Scientific Personnel Division. "Report of Recommendations for the In-Service Graduate Education Study." *Special Consulting Group for the American Council on Education*, January 1948. Mimeographed.

PARKER, J. W. "ECPD Annual Report." *Mechanical Engineering*, Vol. 71, January 1949. pp. 23–25.

POTTER, A. A. "The Forgotten Man in Higher Education." *Journal of Engineering Education*, Vol. 37, June 1947. pp. 777–779.

Purdue University Division of Educational Reference. "A Study of Higher Education for Engineers," by Frank C. Hockema. *Purdue University Studies in Higher Education 59*, 1947.

Contains short bibliography and list of studies in higher education.

ROGERS, H. S. "Gap Between the Statement and Achievement of Objectives in the Education of the Engineer." *Journal of Engineering Education*, Vol. 39, November 1948. pp. 156–161.

SMITH, ELLIOTT DUNLOP. "The Education of Professional Students for Citizenship." *Journal of Engineering Education*, Vol. 39, November 1948. pp. 147–155.

SMITH, J. F. DOWNIE. "The Young Teacher—His Introduction to Engineering Teaching." Paper before Association of Land-Grant Colleges and Universities, Division of Engineering, November 1948. Mimeographed.

TEARE, B. R., JR. "Division of Responsibility Between the College and Industry in the Education of an Engineer." *Journal of Engineering Education*, Vol. 39, January 1949. pp. 272–276.

TEARE, B. R., JR. "The Use of Problems and Instances to Make Education Professional." *Journal of Engineering Education*, Vol. 39, November 1948. pp. 162–170.

Virginia Polytechnic Institute. "Effective Teaching, A Manual for Engineering Instructors," by W. Grant Ireson, Francis J. Maher, Fred C. Morris, and Ralph R. Wright. *Engineering Extension Division Series No. 42*, Vol. 37, August 1944.

Teaching Advanced Mathematics to Electrical Engineering Students

By CECILIE FROEHLICH

Associate Professor of Electrical Engineering, City College of New York

While the understanding of modern Electrical Engineering is based to a great extent on mathematical concepts, there has been a traditional misunderstanding between the professional electrical engineers and the professional mathematicians. Only a few exceptional electrical engineers ever penetrate deeply into the secrets of abstract mathematics and only a minority of mathematicians understand the language of the electrical engineer well enough to be able to apply their extensive knowledge of mathematics to the solution of electrical engineering problems.

With respect to the teaching of mathematics to electrical engineering students this situation has frequently led to a difference in viewpoint of the departments concerned. As a remedy it has sometimes been suggested that engineers with a flair for mathematics be added to the mathematics departments in order to teach the advanced courses in engineering mathematics. Others have suggested the addition of mathematicians to the staff of the electrical engineering departments. These mathematicians, instead of giving the students separate instruction in the advanced mathematical topics needed, would be required to teach those electrical engineering subjects which are predominantly mathematical in nature.

I am such a mathematician, who has ultimately become a member of an electrical engineering department. I therefore thought that it might interest you to hear the conclusions which I have drawn from my experience. In particular, I should like to tell you what I consider to be the most effective method of teaching advanced mathematics to electrical engineering students. I shall call "advanced" for the purpose of this paper those topics which go beyond what is usually taught in a one-year course in college calculus.

Indoctrination of the Mathematician

The mathematician must remember that, in the field of engineering applications, mathematics can seldom play the role of the leading queen, but that in this field mathematics generally has to serve as a humble though highly respected and effective servant. Therefore, in my opinion, a mathematician who wants to teach electrical engineering students successfully in advanced mathematics should go to the trouble of familiarizing himself thoroughly with electrical engineering subjects. He can do so by taking (or teaching!) courses in Electrical Engineering, or better still, by joining a group of electrical engineers and actively participating in some of their research or development projects. The engineers will appreciate his broad knowledge of mathematics and will make constructive use of it, if he will only make an effort to speak and understand their language.

From such experience he will learn to "avoid"—as Maxwell says—"those questions, which though they have elicited the skill of mathematicians have not enlarged our knowledge of science." He will also learn—and I am quoting Maxwell again —that "in certain classes of cases we cannot afford to despise the humbler

method of actually drawing tentative figures on paper." Maxwell is referring to the use of graphical methods in the solution of potential problems, and he adds, "this latter method I think may be of some use even in cases in which the exact solution has been obtained, for I find that an eye knowledge . . . often leads to a right selection of mathematical methods of solution."

But, on the other hand, the mathematician will see that Engineering Mathematics is not just a collection of trivialities consisting of a few elementary graphical and numerical methods for the processing of empirical data and the like, but that there is enough challenge, stimulation and variety in electrical engineering problems to satisfy mathematical ambitions at every level. He will also find out that it is not sufficient to glance through some electrical engineering textbooks, manuals and publications, identify the type of differential equations, functions and operations used and, after such superficial inspection, devise a mathematics course which consists simply of an introduction to all these topics. Such a course, even when interspersed with occasional examples of engineering applications, will be unsatisfactory. If the course is given to students before they have acquired some engineering background, they will not be able to fully understand and appreciate the applications. Unavoidably, too much time will elapse until the mathematical topics treated will reappear in their electrical engineering courses. By then they will not remember what they learned a year ago, or even if they do remember, they will frequently not recognize any connection between the abstract ideas they learned in the mathematics department and the concrete use that is made of these topics in the electrical engineering department.

The Dilemma

It then seems almost a hopeless dilemma: the electrical engineering student cannot obtain the desirable approach to advanced mathematics before he understands the engineering—but he cannot understand the engineering without a certain understanding of advanced mathematics.

The very nature of the dilemma suggests its solution. If advanced mathematics is really inseparable from modern electrical engineering, then it should not be separated from it artificially in the electrical engineering curriculum.

It is neither necessary nor sufficient to have formal courses in mathematics beyond the elements of calculus as a preparation for the understanding of electrical (or other) engineering courses. Whatever advanced mathematics is needed can be taught much more effectively if it is introduced gradually in the engineering courses, each topic being explained when and where it is needed. This "from hand to mouth" method may result in a very unsystematic introduction, unsystematic from the mathematician's viewpoint. But you must remember that the interest of the ordinary electrical engineering student is primarily in electrical engineering and only secondarily in mathematics. He will therefore understand, absorb and appreciate the material better when it is interwoven into his gradually increasing engineering experience. At the same time he will be protected against the common danger of acquiring the knowledge of higher mathematics without learning when, where and how to use it (and—even more important—when and where to avoid it!).

I do not want to advocate narrow specialization, nor am I overlooking the fact that mathematical disciplines which seem to be high-brow today, comprehended by a small group of professional mathematicians only, may be the everyday tools in the hands of engineers tomorrow. I also consider it highly important not to keep the student from seeing that mathematical principles and methods developed for one branch of science or engineering may be equally applied to other branches. I do advocate, however, that basic mathematical concepts be formed in the mind of the electrical engineering student—

over a period of two or three years—step by step, by abstraction and generalization from special cases as they arise. I consider this method as pedagogically superior to the teaching of abstract mathematics first, followed by the teaching of applications as examples. By this method the student will have gained at least the same amount of basic mathematical background at the end of his senior or first graduate year as the engineering student who has received his mathematical instruction in one of the traditional introductory courses to engineering mathematics.

The abstraction will have gone far enough to enable him to recognize and make efficient use of existing analogies in seemingly different fields. It will, however, not have been pushed to the degree where mathematics frees itself from all earthly bounds, loses the ground under its feet and rises to become the queen of sciences obeying no other laws than her own. Few are destined or capable of climbing to these heights, still fewer are capable of deriving from such experience valuable knowledge with which to discover and open up new areas of engineering science. For these few who are qualified to pursue independent research, a mathematical education beyond the senior or first graduate year will be of greatest value. Their education should include courses in advanced mathematics without regard to immediate engineering applications and their study of mathematics should be limited in scope only by their own tastes and desires. The undergraduate and first year graduate electrical engineering education, as I conceive it, will have given every Electrical Engineering student (as a by-product) an appreciation of the power of advanced mathematics, a view of many of its branches and a fair opportunity of testing his own mathematical talents.

Coordination of Mathematics and Examples of Engineering

You will probably want to see from concrete examples how the proposed interlinkage between mathematical and electrical engineering instruction can be realized. Instead of giving you isolated examples, let me take you briefly through one phase of the electrical engineering curriculum.

I choose for this purpose the sequence of courses on linear circuits, lines and networks. Such a sequence will take from four to five terms. It may start out with an introduction to d.c. circuit analysis, which is commonly taught as part of a first course in electrical engineering in the sophomore year. After some introductory examples the systematization of d.c. circuit analysis for n-mesh or n-node networks will give the opportunity of either introducing or reviewing the solution of systems of nonhomogeneous linear algebraic equations by means of determinants. The expansion of determinants in minors will serve to bring out the fundamental nature of the principles of superposition and reciprocity, common to all linear systems.

In such a first electrical engineering course the elementary phenomena occurring in the disenergizing and the d.c. energizing of coils or condensers are also generally taken up. These topics will give an opportunity for a meaningful introduction or review of the exponential function. The student may be told, incidentally, that the equations he has set up and solved are first-order linear differential equations with constant coefficients. His attention may be drawn to the importance of the initial conditions and (with a view to later generalization) to the fact that the solution in the nonhomogeneous case has been gotten by superposition of the steady state term (a particular integral) and the transient term (the solution of the homogeneous equation).

In the course on a.c. circuit analysis which conventionally follows in the electrical engineering curriculum, attention will be focussed on the "steady state solution." This is the particular integral of Kirchhoff's equation which corresponds to the forced sinusoidal response to sinus-

oidal excitation of the same frequency. After a few preliminary exercises the student will be impressed by the fact that each a.c. steady state term of given frequency may be completely characterized by a pair of two numbers. The scene is thus set for the introduction of complex numbers and their representation in the complex plane. The exponential function will naturally reappear, this time with purely imaginary argument. It will serve to reduce the a.c. network equations from a system of linear nonhomogeneous integro-differential equations with constant coefficients to a system of nonhomogeneous linear algebraic equations, thus bringing steady state a.c. network analysis within the reach of the algebra of linear systems.

In order to reach the same goal for periodic current and voltage excitation of other than sinusoidal shape, Fourier series in trigonometric and exponential form will subsequently be introduced. In the same part of the course harmonic analysis of empirical waves will provide a good opportunity to emphasize and teach the organizing of extended numerical calculations by means of schedules.

In most schools the a.c. steady state circuit analysis will be followed by a general introduction to transient phenomena. This will give an opportunity for a systematic study of systems of homogeneous and nonhomogeneous linear differential (or integro-differential) equations with constant coefficients. Exponential functions with complex arguments will thereby naturally enter into the picture. The students perception and visualization of exponential, trigonometric and hyperbolic functions and their interrelations in the complex domain will be further advanced in the following course where steady state analysis of filters and transmission lines will be taken up. (It will, incidentally, be greatly helped by the use of three dimensional relief representations of these functions). If the transmission line is used as a link in a power or communication system it may be interpreted as just another four terminal network whose steady state current and voltage at the sending end are linear transformations of the corresponding variables at the receiving end. Systematization of four terminal network analysis will at this point lead to a natural introduction of the elements of matrix algebra.

But while the study of transmission lines has its place in the electrical engineering curriculum because of its immediate practical application in power and communication systems, it is just as valuable as an introduction to the phenomena of general wave propagation. It gives an opportunity to acquaint the student with some aspects of partial differential equations and the solution of boundary problems. However, electrical engineers do not work out each boundary problem separately as if it were a new problem. They coordinate results by deriving general principles which they express in terms of "wave impedances," "reflection coefficients" and the like. While all these engineering concepts have their origin in the solution of boundary problems, they make it unnecessary to return to the basic equations in each new case. The development of such concepts is of primary importance, not just a matter of economy in time. In engineering, analysis generally constitutes only a necessary step towards the ultimate goal. The ultimate goal is design and not analysis.

Systems of ordinary or partial differential equations are extremely unwieldy tools in the hands of the designer. It is therefore not surprising that electrical engineers have always gone all out —legally and illegally—for "operational" methods. In the students senior or first graduate year transient network analysis is reconsidered under this aspect. Function transforms which result in the translation of complicated problems in the original function domain into simpler problems in the transform domain will receive his undivided attention. The concept of the Fourier Integral, interpreted in terms of frequency spectrum analysis, is basic for the communication engineer. While mostly unsuited for the purpose of

the explicit solution of individual network problems, the idea of spectrum analysis makes meaningful the creation of easily manageable fictional networks with idealized characteristics.

The Laplace Transform will provide the final link between the a.c. steady state and the transient performance of networks. Naturally the consideration of the Laplace transform and its inverse will lead to an excursion into the theory of complex functions. Only a few theorems on complex integration will be needed, but the student's knowledge of complex functions will be supplemented when he learns to appreciate their power in the solution of two dimensional potential field problems.

Such problems will come up in a different sequence of electrical engineering courses. In this sequence which also extends from about the sophomore to the senior or first year graduate level, a gradual understanding of electromagnetic field and wave phenomena is achieved. It begins with an introduction to the primitive concept of the magnetic circuit, so indispensable for the design of machines and transformers. It builds up gradually to the point where the basic operations of vector analysis will be abstracted from already familiar field concepts and where Maxwell's equations can be introduced to the electrical engineering student as a natural generalization of transformer laws. The discussion of such items as wave propagation, wave guides, resonant cavities and antennas will follow. They will necessitate the solution of various boundary problems and thereby lead to the gradual introduction of many higher functions. I do not intend to lead you through every detail of this phase of the electrical engineering curriculum, because I do not consider it to be really relevant just when and where every single mathematical topic may be introduced.

It is however relevant, in my opinion, that a new mathematical tool be only introduced at such a point in the course where the student can appreciate its necessity. I also consider it essential, for good teaching practice, to introduce new mathematical concepts always in such a way as to impress the student with the fact that the purpose of higher mathematics in engineering is to simplify matters and not to complicate them. I have found that by using this philosophy, the teaching of mathematics to electrical engineering students can be a most gratifying experience.

College Notes

A $1,700,000 laboratory for the study of materials and methods of processing them will become the second unit in **Cornell University's** new engineering development. The Materials Laboratory will house the Departments of Mechanics and Engineering Materials and will contain some of the laboratories of the Department of Engineering Physics. Special facilities will be provided for research in photoelasticity and other methods of experimental stress analysis and for spectroscopy and radiography. The other unit will house the Materials Processing Department of Sibley School of Mechanical Engineering and will have facilities for research in machine tool production methods, the machining of metals and the development of plant layouts for manufacturing purposes.

Clarification of Equations for Simple Forced Vibration

BY BLAKE D. MILLS, JR.
Professor of Mechanical Engineering, University of Washington

In teaching an elementary vibration course from various textbooks, the author has encountered an aspect of simple forced vibration which the textbooks do not make clear. Students have been confused by what seemed to them to be a contradiction between books; yet it should be a straightforward fundamental concept. The textbook material is not actually erroneous, but it has been misleading to students.

The matter involves only the simplest possible condition for forced vibration, i.e., a harmonic force acting on a mass which is supported on a linear spring, with no damping. Figure 1 is a typical sketch representing this condition. The problem is to determine the motion of the mass, after the harmonic force has begun to act on it. Most vibration textbooks show a solution for this problem. None, however, seems to point out that the maximum vibratory displacement of the mass depends a great deal upon the phase of the harmonic force at the instant it is first applied to the mass.

When it first acts on the mass, the force may be going through its maximum value, through its zero value, or it may have any intermediate value. Let the time t equal zero when the force begins to act. Then, in the first case the force can be expressed as $F \cos \omega t$, and in the second case as $F \sin \omega t$. All the vibration textbooks seem to use one or the other of these types of expression for the force, with preference about equally divided. The choice between $F \cos \omega t$ and $F \sin \omega t$ might seem trivial, but let us see what difference it makes in the final expression for displacement in terms of time, and in the maximum vibratory displacement.

Let the force frequency be ω and the natural frequency be ω_n, in units of radians per second. Assume that the mass is at rest in its equilibrium position, at the instant that the harmonic force begins to act on it, i.e., when time $t = 0$.

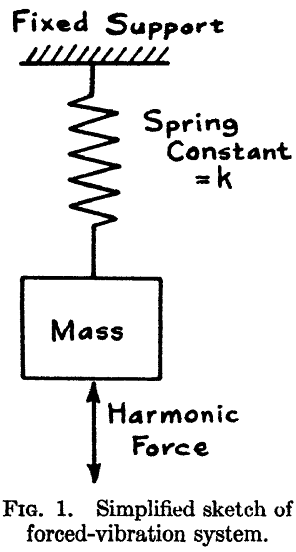


FIG. 1. Simplified sketch of forced-vibration system.

Now let us solve for the instantaneous displacement of the mass from its equilibrium position, at any time t.

If the harmonic force is represented by the expression $F \cos \omega t$, we find that the displacement x at any time t is given by the following equation:

$$x = C \cos \omega t - C \cos \omega_n t, \qquad (1)$$

where

$$C = \frac{F/k}{1 - (\omega/\omega_n)^2}.$$

However, if the harmonic force is $F \sin \omega t$, instead of $F \cos \omega t$, the following quite different equation is obtained:

$$x = C \sin \omega t - C\left(\frac{\omega}{\omega_n}\right) \sin \omega_n t, \quad (2)$$

with C as before.

In Equations (1) and (2), the amplitude of the first term or "forced vibration component" is the same, and it is equal to the constant C. The amplitude of the second term or "free vibration component," however, is not the same in the two equations. It is equal to C in Equation (1), but it is $C\left(\frac{\omega}{\omega_n}\right)$ in Equation (2). This difference has a great effect on the

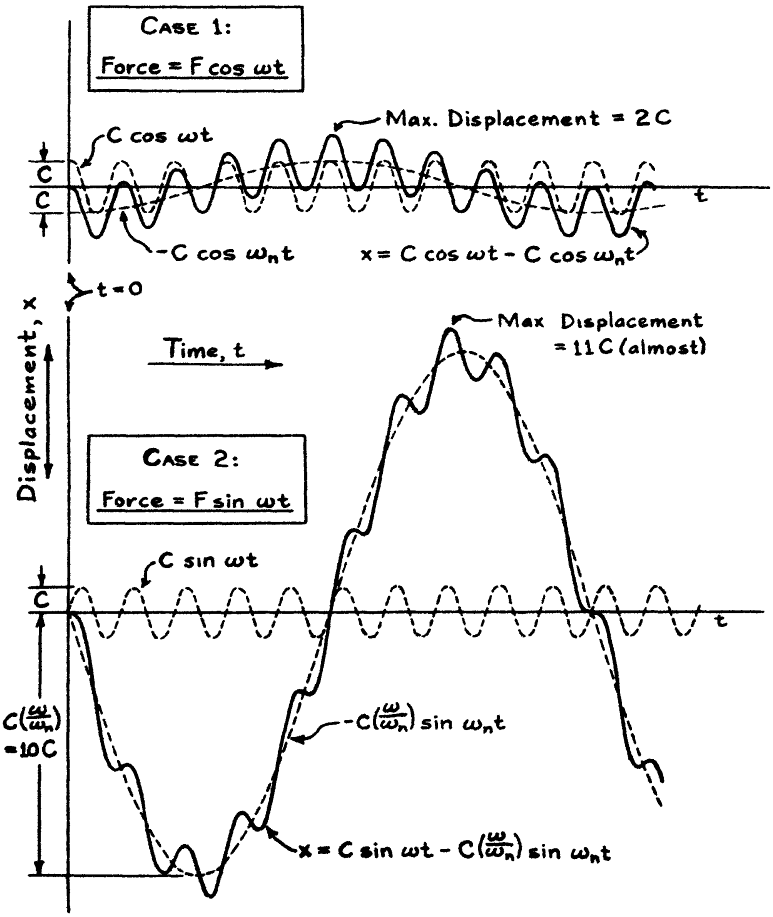


FIG. 2. Time-displacement curves for motion of the mass after application of a harmonic force.

Legend: $\omega/2\pi$ = force frequency = 10 cycles per second.
$\omega_n/2\pi$ = natural frequency = 1 cycle per second.

$$\text{Constant } C = \frac{F/k}{1 - (\omega/\omega_n)^2} \cdot \frac{\omega}{\omega_n} = 10.$$

resultant motion of the mass, if the force frequency is much different from the natural frequency.

Take, for example, an instance where the frequency of the force is 10 cycles per second, and the natural frequency is one cycle per second. Figure 2 shows graphically the motion of the mass, from the time of initial application of the force, for the respective cases where the harmonic force is $F \cos \omega t$ or $F \sin \omega t$. These curves represent Equations (1) and (2), respectively. It is to be noted that the peak displacement on one curve is over *five times* as great as on the other curve. With no damping, this situation would continue indefinitely. In practical situations, the free vibration component would eventually vanish due to damping, and the steady-state vibration would then have the amplitude C. However, in the event of sudden application of a large harmonic force, the first high peaks of the displacement might well cause damage before the free-vibration component is sufficiently reduced by damping.

Suppose that a student approaches the problem just quoted, wherein a 10-cycle-per-second harmonic force acts on a system whose natural frequency is one cycle per second. If he follows any of four well-known vibration books, he finds the peak displacement to be *two* times the constant C. If he follows any of four other equally well-known vibration books, he finds the peak displacement to be *eleven* times the same constant C. Who is wrong? No one, actually, since four books consider the applied force as $F \cos \omega t$, and the other four books treat the case of $F \sin \omega t$. But none of the books makes any mention of the fact that the choice between $F \cos \omega t$ and $F \sin \omega t$ to represent the force would make a significant difference in the resulting motion of the mass. A brief explanation of that fact, in this author's opinion, would contribute a valuable clarification from the students' point of view.

In an actual situation, the initial value of the harmonic force would probably be neither the maximum value nor zero, but something in between. In that case, the force can be represented as the sum of a cosine component and a sine component: $F_1 \cos \omega t + F_2 \sin \omega t$. Upon solving for the displacement in terms of time, we obtain an equation which can be put in the following form:

$$x = C_1 \cos \omega t - C_1 \cos \omega_n t + C_2 \sin \omega t - C_2 \left(\frac{\omega}{\omega_n} \right) \sin \omega_n t, \quad (3)$$

where

$$C_1 = \frac{F_1/k}{1 - (\omega/\omega_n)^2},$$

and

$$C_2 = \frac{F_2/k}{1 - (\omega/\omega_n)^2}.$$

Equation (3) is an expression which essentially combines the separate solutions for the special cases where the force is $F \cos \omega t$ or $F \sin \omega t$. From Equation (3), the peak displacements for the intermediate cases are seen to lie between the values for the special cases represented by Equations (1) and (2). The textbooks have covered the one extreme case or the other, but have not taken up the much more likely intermediate cases, represented by Equation (3).

The author does not present this matter as one of great importance in practical applications, since damping usually allows the free-vibration component to be safely neglected. However, that component can be important in certain instances. In any event, future textbook treatment of the subject might well afford to clarify the significance of choosing between $F \cos \omega t$ and $F \sin \omega t$ to represent the applied harmonic force.

Appendix

In the preceding discussion, the first special case taken up is where the applied harmonic force is represented by an expression of the form $F \cos \omega t$. The motion of the mass is then represented by

an equation of the form:

$$x = C \cos \omega t - C \cos \omega_n t, \quad (1)$$

where

$$C = \frac{F/k}{1 - (\omega/\omega_n)^2}.$$

The following textbooks use the equivalent of $F \cos \omega t$ for the force, and show a solution equivalent to Equation (1). Some of the books do not show the solution for forced vibration *without* damping, but they show a solution which becomes equivalent to Equation (1) when the damping factor is set equal to zero.

"Vibration Problems in Engineering" (First Edition), by Timoshenko (1928). Page 12.
"Vibration Prevention in Engineering," by Kimball (1932). Page 30.
"Elements of Mechanical Vibration" (First and Second Editions), by Freberg and Kemler (1943 and 1949). Page 32 in each edition.
"Advanced Dynamics," by Timoshenko and Young (1948). Page 41. (This book also takes up the application of any type of applied force, with the use of Duhamel's integral.)

In the second special case, the applied harmonic force is of the form $F \sin \omega t$. The motion of the mass is then represented by an equation of the form:

$$x = C \sin \omega t - C \left(\frac{\omega}{\omega_n} \right) \sin \omega_n t, \quad (2)$$

with C as before.

The following textbooks use the equivalent of $F \sin \omega t$ for the force, and show a solution equivalent to Equation (2), or one which is reducible to Equation (2) by setting the damping factor to zero:

"Vibration Problems in Engineering" (Second Edition), by Timoshenko (1937). Page 17.
"Fundamentals of Vibration Study," by Manley (1942). Page 24.
"Mechanical Vibrations," by Thomson (1948). Page 64.
"Mechanical Vibrations" (First, Second and Third Editions), by Den Hartog (1934, 1940 and 1947). First Edition: Page 50. Second Edition: Page 56. Third Edition: Page 58.

The following textbooks do not consider the free-vibration component in their discussions of forced vibration, and hence do not show solutions for the problem under present consideration:

"Vibration Analysis," by Myklestad (1944).
"Elementary Mechanical Vibrations," by Church (1948).

Summer Schools

The Executive Board has approved the following Summer Schools which will be held at Michigan State College either before or immediately after the Annual Meeting in June, 1951:

Engineering Drawing—June 21–24, 1951

Humanistic-Social Studies—June 21–23, 1951

Mechanical Engineering—Thermodynamics—July 2, 1951 (for 2 weeks)

Survey of the Teaching of Economics and Related Subjects to Engineers

By ALBERT J. SCHWIEGER
Head, Department of Economics, Worcester Polytechnic Institute

Much has been written about the importance of training in Economics and related subjects for engineers. Little has been reported on that which is being taught and how. To secure this information 43 engineering schools and engineering divisions of universities were surveyed in 1949 by the writer and his colleague, Professor Ernest D. Phelps. The schools reporting are listed at the end of this article. They include all types of engineering schools in every section of the nation and probably give a fair sample of current conditions in engineering teaching.

At the outset it should be stated that the statistical results obtained will be of little help to any school looking for averages. The reports indicated so much disagreement that the average of what is being done is of no validity.

Economics

Only the work in straight engineering curricula were studied. Principal attention was directed toward the teaching of introductory economics since this is considered a basic course. Thirty-four or about 80% of the schools required economics of all students. Twelve or about a third of these required a six semester hour course. A like number required a three hour course. Six specified four hours; two required only two hours; and to scheduled courses of eight and nine hours respectively.

Significantly, nine or about 20% did *not* require a regular economics course of all engineers. To be sure three of these required a social science survey or general studies course which included some economics. Two required economics of some engineers and two listed it optional. However, two colleges left economics out of the curriculum completely.

The nature of the courses in economics also varied considerably. However, it is possible to roughly divide them into two broad groups: the traditional economics course, and the course specially adapted to the "needs" of engineers. Twenty four or about 70% were traditional courses of the more or less traditional economic-principles pattern. The remaining ten schools varied this approach in one or more of the following ways: (1) greater emphasis on production techniques and responsibilities; (2) use of problems or "cases" to an unusual degree to give a more practical slanting; (3) choice of instructors with scientific training and interests to modify the approach and illustrations.

About half of the schools reported that attention had been given to the problem of integrating or correlating the work in economics with that in allied fields. An almost equal number were not concerned with this problem.

Some thirty different textbooks were used almost all of them standard books. The leaders were Samuelson, "Economics"; Kiekhafer, "Economic Principles Problems and Policies"; Meyers, "Elements of Modern Economics"; with nine, four, three adoptions, respectively. Most schools did not attempt to supplement the course with visual aids, economic re-

ports, outside speakers, plant visits or discussion groups; though there were notable exceptions to this in a few colleges.

Subjects related to economics were required by twenty-eight or about 65% of the reporting schools. In some cases these were specified for all engineers and in some for just certain departments. These same courses were elective at many of the colleges. In addition several schools offered a wide range of advanced economics electives. Though the specific titles varied somewhat it is possible to summarize them under seven commonly accepted course titles as follows:

	No Schools Requiring		No Schools Elective
	All Depts	Some Depts	
Engineering Economy	9	6	2
Business Law	4	7	10
Business Organization and Management	2	9	6
Accounting	3	4	11
Psychology or Human Relations	3	1	8
Production Engineering	1	2	2
Personnel	2		5
Labor		2	8

Opinions of the Economics Course

After filling in the questionnaire, the educators were asked to comment on their needs, accomplishments and plans for courses in this area. While the comments were few in number they reflect views which the writers believe are probably rather widespread. Only one engineering staff member expressed general satisfaction with the present handling of economics. Others who did not comment may have been satisfied and believed that no comment was necessary.

There were a number of comments which revealed dissatisfaction. To quote:

"Since the principles course in Economics does not yet fit our needs, we are postponing requiring it."

"We have been very conscious of this problem for a long while and have failed thus far to reach a satisfactory understanding of our needs by the Department of Economics; hence we are experimenting with an unpublished text (by a former industrial economist) with a trial section."

"It is our general feeling that the field of economics in so far as it is related to Engineering must enter into many of the upper division Engineering Courses, that is the Engineering instructors in the courses of the third and fourth years must themselves appreciate the place and significance of economics in relation to the material which they present." (No economics was required at this school.)

Another college reported that a committee had been appointed by the Dean of Engineering to "explore the possibilities of greater cooperation between the social science departments and the College of Engineering."

Several of the engineering teachers were of the opinion that the traditional economics course was not what was needed by engineers. As one Director of an Industrial Management School wrote, "Engineers have not as yet come around to believing that work in our field is essential—not over-anxious. Of course there are exceptions among students and faculty."

The few economists who commented were of a different opinion. "I consider this (special course for engineers) inadvisable. We discussed it at length but felt that what was needed was a good principles course. After all, there simply is not one brand of economics for engineers, and, say another for pre-medics. Moreover, splitting up courses is pedagogically bad." Another wrote, economics is "intended as a general cultural course, and is not vocationally directed. We feel that our other students gain from coming in contact with the point of view of the engineers and that the gain is not uni-directional."

Observations and Conclusions

One searches fruitlessly in the reports of these representative schools for any commonly accepted pattern of curricula in this area, not only among the reporting schools but among engineering departments in the same school. Engineering educators write and speak emphatically about the common needs in this area, but the curricula do not reflect their opinions.

The conclusion seems fairly clear that neither engineering educators nor teachers of economics and allied subjects are fully satisfied with the present handling of courses in this area. After years of experimentation it is well that the situation be objectively appraised. There is a real need to get below the level of departmental bickering and personal recrimination at which the problem is all too often attached.

The Committee on Engineering Education after the war of ASEE has clearly stated the need of engineering students for "the acquirement of the ability to understand, to analyze, and to express the essentials of economic, social, or humanistic situations or problems, and to appreciate the implications and relationships of such problems to the life and work of an engineer." This is the ideal goal which is given to teachers of the humanistic-social stem subjects. The word "ideal" needs to be stressed for the practicability of such a goal has been too seldom challenged. Unrealizable goals may be a major source of the dissatisfaction with engineering education in this area. Suppose we consider two aspects of this question.

First as to the size and complexity of the stated goal. Here is an area of human knowledge which is probably wider and more detailed in its scope than all of engineering science. Liberal arts colleges would consider this goal as a fair one to aim for with a four year program exclusively devoted to it. Is it realistic to expect to accomplish it as a sideline along with engineering? Is it any wonder that attempting to do so frustrates the humanistic-social science service staff and disappoints the engineering college administrators? Realization of the difficulty, if not impossibility, of accomplishing this goal in the time alloted may well be the first step toward some lessor but practicable goal.

Second, consider the feasibility of economics as a course to meet needs in the area blocked out by the Hammond Committee. Part of the difficulty here is due to a misconception on the part of engineers as to just what economics is and what competent economists can be expected to contribute. Economics is only one of the social sciences and a year or a semester course of it cannot supply a complete introduction to social science and business concepts. Its usefulness in adding to the "plus" side of engineering has been oversold to the sorrow of those of us who try to "deliver the goods." Unfortunately somewhere along the line of development, economics appeared to be a handy packaged way to meet the needs expressed by engineers for greater social and business understanding. The idea caught on and the illusion has persisted.

Lack of realization of the two points mentioned above as hard facts has kept school after school fruitlessly searching for the "right approach," the "right text" and the "right instructor" to "meet the needs." Recently a few colleges have undertaken to experiment with broad, newly conceived general survey or general studies courses. This gets away from the inherent incompleteness of economics, but it still attempts the enormous task of coverage mentioned above. The time allotted for such courses is so limited that the seven-league-boot strides of the teacher may well leave the student dizzy or discouraged. The engineer who is attracted by the newness of these courses should properly adjust his expectations by asking himself what he could expect to do in a similar time toward giving a survey of all of the engineering sciences to liberal

art students who enter his course as a minor sideline to non-engineering studies.

Real study to arrive at a systematic, realistic, planned attempt to broaden the understanding of undergraduates in this area is long overdue. Except in isolated instances, efforts have too often stopped with a statement of goals and minor adjustments. In the meantime many of the engineers and economists carry on their cold war of dogma. An impartial expert commission of engineers, social scientists, and business educators could help bring understanding and agreement as to optimum use of the precious time set aside in curricula in a hope that more good will come out of it toward the goal stated by the Hammond Committee. Probably those who are experimenting with genuine attempts to synthesis the social sciences for engineers are on the right track. Probably the problem of time limitation could be partly relieved by economically weaving some of the teaching into the existing engineering courses. Some such solution may be the only way to get satisfactory results within four years. This will not be easy for there is very little experience to go on. Subject matter orientation and teaching materials are largely lacking. Lacking also are enough engineering instructors capable of giving the wider scope to their technical specialties. None of these difficulties, however, should deter some genuine cooperative spadework by a determined team of workers as suggested above. The record is clear that half measures will not meet the need with which engineering educators are struggling.

Visual Aids in Education

By WALTER L. SHILTS
Head, Civil Engineering Department, University of Notre Dame

In the category of visual aids we may include anything other than the textbook, which the student may see, and which will thereby aid him in any manner to acquire a better knowledge and understanding of the matter under discussion. We might also add, anything which will enable him to acquire the same knowledge and understanding in less time.

In the discussion of visual aids, the matter of time is of the utmost importance. In a curriculum which is badly over-crowded, every credit hour must be justified. Because of poor presentation and development, a course of three hours credit may be made to cover only material which should be presented in two hours. Visual aids or any other kind of aids should serve to reduce, not increase, time—so that more matter can be covered in the allotted three hours, or so that the same matter can be covered in two hours rather than three and the extra hour given up to something else. Every kind of teaching aid considered should be given a cold-blooded scrutiny, and ruthlessly rejected if it does not meet the above requirement.

The simplest and most obvious visual aid is the blackboard and chalk, without which we would all have to drastically change our teaching methods. It is undoubtedly the visual aid with which we could least dispense, and the most versatile of all aids. A teacher of Engineering should develop the art of technical sketching so that when he wishes to illustrate a point, he can quickly produce a sketch which is legible and a reasonable facsimile of what he is trying to show. To be most effective, the sketch must frequently be made without warning, in answer to an unexpected question from a student. If properly developed, this art of quick sketching can be made a powerful teaching tool.

Time Saving Element

Many illustrations, diagrams, tables, and the like appear in textbooks and technical journals. We all find the need of referring to and discussing these at times, and have all encountered difficulty in doing so. It would use up too much valuable time to reproduce these on the blackboard. This difficulty can be eliminated by the use of an opaque projector, which will enable the instructor to reproduce the figure on a screen, and point out whatever he wishes to call to the attention of the class. If it is something to be used often, a slide can be made of it, and used for projection with somewhat greater satisfaction. Slides can also be made, showing tables, curves, diagrams, etc., not found in a book, and projected for discussion and explanation before a class. This can probably be done more economically and effectively on a departmental, rather than individual basis, if all members of the department cooperate in the making of the slides—particularly for courses in which different sections are taught by different teachers. To be effective, these must be carefully made—so that when projected they can be read by the audience, and the instructor can omit the apology frequently heard, "Of course you can't read these figures, but. . . ."

There are also slides and films which may be obtained from industrial con-

cerns. Many of these are worth while, and will show the student something which it is almost impossible to show otherwise. With few exceptions, however, even the best of these industrial films take more time than needed to illustrate a point for college students—or we may say they are not quite on college level. And some of them are of a grade which could only be called entertainment. If an instructor makes use of these industrial sources, he must certainly preview the films and slides and omit those which are not of high educational level and which do not meet his particular requirement.

One of the latest aids in this line, the Vu-graph, is a machine which, as the teacher writes or draws at a desk, will project this writing or drawing on a screen as it is being done. The same machine will project slides or opaque views.

In many cases, charts, tables, graphs, and the like can be made to large scale and hung on the wall before a class—large enough to be readily visible to all. They should be of the size and character of a good projected slide.

Models Helpful

Models of various and sundry kinds are helpful. I have found that students in Strength of Materials, sometimes are unable to solve fairly simple problems, because they do not have the correct notion of an angle, channel, or I-beam section. A display of short pieces of these sections is of tremendous aid to them. Here again a departmental collection is probably better than an individual one, but sometimes it takes an individual to spark the department—or shall I say the Departmental Head?

In courses accompanied by laboratory work, the ideal condition is to have the laboratory in the classroom or to hold class in the laboratory—so that as a principle is discussed it may immediately be demonstrated. With our crowded enrollment and schedules this is in most cases impossible, although in some courses a demonstration period is included so that this condition is approached. Some use can be made of demonstration tables on wheels, so that for certain purposes a small portable laboratory is wheeled into the classroom. But do we all make as great an effort as we can to correlate theory and laboratory work? If not, the effectiveness of the laboratory as a visual aid is greatly diminished.

Most of us, I presume, use mimeographed notes, examinations, etc. If not, why not? I am reminded here of the student who sat with a bored look in the back of the classroom while the teacher filled the board with material which he desired the class to reproduce in their notebooks. At the end of the period, while everyone else had writer's cramp from scribbling notes which they would have difficulty reading later, this boy stood up, pulled out a candid camera, took a photograph of the board, and walked out of the room.

Some of the aids mentioned herein are expensive and difficult to acquire or make, and take a lot of valuable time Some which are used consume more time than their value warrants. But let us not miss the simple and obvious aids and time-savers—which I am afraid many of us do at times.

The Lamme Medal

To receive the Lamme Medal is a very high honor; to date twenty-three distinguished educators have been given the honor. A committee of twelve is charged with the final selection, but the Committee is very anxious for the membership to participate. Each year a notice is published in the JOURNAL OF ENGINEERING EDUCATION requesting nominations, and each year one or two names are presented from a membership of nearly seven thousand. Two nominations do not comprise enough membership participation; there should be an avalanche of good suggestions.

Among the membership of the Society there are hundreds of teachers and administrators who fulfill the requirements set out by the Committee many years ago:

1. Achievements which can be taken as proof of excellence in teaching or as having contributed to the art of technical training, will be given major consideration.
2. Only those achievements will be considered which seem to have the possibility of lasting influence or which have sufficiently stood the test of time.
3. Books, articles, contributions to method and research, which have a beneficial effect upon the teaching of engineering, will be given considerable weight in making the decision.
4. Participation in the work of Engineering and Educational Societies is not necessary for eligibility. Such participation, however, will be given due consideration if it has led to definite and recognized results in bettering technical education.
5. Achievements outside of the field of teaching, such as employment in industry, consulting work, inventions, etc., will be considered as of secondary importance in making the award.
6. Administrators in engineering schools are eligible. Only that work of Administrators, however, will be considered which has led to definite and recognized improvements in method of teaching or in the art of technical training.
7. Emeritus Professors are eligible.

Nominations should emphasize the contributions of candidates to these major objectives. Any member of the Society may place a name before the Committee by giving a brief outline of achievements which qualify the nominee for consideration. The Committee prefers individual nominations to group nominations which result from a campaign by some member, though spontaneous group endorsement is a very satisfactory way to nominate.

The Committee suggests that statements regarding nominees be made according to the following outline:

1. Preparation for teaching work—school, year graduated, degree, postgraduate work, honorary degrees.
2. Accomplishments as a teacher.
3. Advancement of the art of technical training—books, articles, contributions to method, research, etc.
4. Administrative work in engineering schools.
5. Membership and participation in Engineering and Educational Societies.
6. Engineering practice—employment in industry, consulting work, inventions, etc.
7. Other achievements.

Nominations should be sent to the Chairman of the Committee, Nathan W. Dougherty, University of Tennessee, Knoxville, Tennessee, by January 1, 1951.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1000, together with an engraved certificate. The recipient is selected by a ten-man committee, nine of whom are appointed by the President of the Society. There is also a representative from the Foundation. The Award for 1951 will be presented at the banquet of the annual convention at Michigan State College, East Lansing, Michigan, June 25–29, 1951.

The recipient of the Award must have made a significant contribution to the teaching of engineering students and shall have distinguished himself in several of the following ways:

1. Record as a teacher. (Evidence of superior teaching and guidance of students as demonstrated by records of former students, indications of unusual subject matter competence, etc.)
2. Improvements of the tools of teaching. (Textbooks and student notes, descriptions of special courses or curricula, diagrams and models, new laboratory and teaching equipment, etc.)
3. Other activities contributing to the improvement of teaching. (Material relating to the development of teachers in the nominee's department or teachers in general, the development of testing and guidance program for students, the promotion of cooperation with other types of educational units or with industry, coordination of fields of subject matter, etc.)
4. Evidence of high intellectual capacity. (Brilliance of mind as manifested by contributions to literature, degrees and honors received, etc.)

The Award has been established to encourage younger men who have shown by their past record evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before March 1, 1951, to the Chairman of the Committee on Award, Dean R. E. Vivian, University of Southern California, Los Angeles 7, California. Nominations must be made on forms available from either the chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

James H. McGraw Award in Technical Institute Education

The purpose of this award is to recognize and encourage outstanding contributions to technical institute education. Candidates for it may be teachers, authors, or administrators who are, or have been, affiliated with an institution which offers or sponsors training of the technical institute type.

This is an annual award of the sum of \$500, and it is made at the annual dinner of the Technical Institute Division of the American Society of Engineering Education each June. It is made upon the recommendation of the James H. McGraw Award Committee, members of which are appointed annually by the president of the American Society of Engineering Education. Nominations for the award should be sent to the chairman of the Committee, Professor H. P. Rodes, University of California, Los Angeles, California. The award is made possible by the McGraw-Hill Book Company in memory of James H. McGraw.

Important Notice

Shorter, Less Expensive Pre-Engineering Test Now Available

With the aid of the joint ASEE–ECPD Advisory Council the Measurement and Guidance Project in Engineering Education has devised certain improved testing services for engineering colleges.

I. To meet the need for a short, inexpensive, and easily administered test generally quite predictive of scholastic success in engineering colleges, a *new 80-minute Pre-Engineering Ability Test* will be offered for sale by Educational Testing Service on and after July 1, 1951.

Derived from the two most predictive parts of the Pre-Engineering Inventory, the new 80-minute test is estimated to have a validity nearly as high as for the composite score from the Inventory. Norms carefully equated to the original national norms will be furnished so that the test can be effectively used as soon as purchased.

A cost of 12 to 15 cents per examinee for test materials is made possible by separate answer sheets and reuse of each test book four to six times. Answer sheets and test books will be sold in packages of twenty-five; answer sheets for 80 cents per package; books for 40 cents each or \$10 per package. Scoring stencils are 25 cents each (only one is needed). The sale of tests in restricted to colleges and to technical institutes accredited by ECPD.

II. After January 1, 1951, users of the Pre-Engineering Inventory who prefer to continue to use the four-hour "Short Form" or the six-hour "Long Form" may *purchase* test books, answer sheets, and scoring keys. Only engineering colleges and ECPD accredited technical institutes

may purchase the tests. A cost of 50 to 60 cents per examinee is made possible by separate answer sheets and reuse of test books four to six times.

Under this new plan the costs are as follows:

	Test Books	Answer Sheets	Scoring Stencils
Unit of Sale	One book or one set of two books	Package of 25 sets	One set
Cost			
Short Form	$1.50 per book	$2 per package	$1 (4, one for each test)
Long Form	$2 per set of two books, I and II	$2.50 per package	$1.50 (7, one for each test)

Some of the test books may have been used previously but all are in excellent condition. Books usually can be reused five to eight times. Only the inexpensive answer sheets need be repurchased.

Educational Testing Service will score and report scores on an alphabetical list at a cost of $1 per examinee for the Short Form, $2 per examinee for the Long Form. For an additional $0.75 per examinee, distributions will be furnished comparing the group tested against national norms.

Individual announcements of these new services have been mailed to deans of engineering and to other interested persons. Further information may be obtained from Dr. A. Pemberton Johnson, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

ANNUAL MEETING

June 25–29, 1951

MICHIGAN STATE COLLEGE

East Lansing, Michigan

Industrial Research and Its Effect on Industrial Trends in the Pacific Northwest*

By DON W. WALTERS

Managing Engineer, Inland Empire Industrial Research, Inc., Spokane, Washington

The industrial outlook of this great Pacific Northwest has appeared in the national limelight on many occasions. Perhaps the most forceful incident took place recently in the dedication of the great Grand Coulee Dam. This event caused the editors of the nation's newspapers and magazines to take more than just a cursory glance at the Pacific Northwest, and much publicity appeared in both the newspapers and magazines, analyzing and forecasting our tremendous future industrial growth.

In the May 15th issue of *Time* Magazine there appeared an article entitled, "Land of the Big Blue River," describing the Grand Coulee Dam and presumably evaluating the effect of the Columbia River hydroelectric power development on the economy of the region. I quote from this article a paragraph, headed "Out of the Wilderness":

> "World War II tripped off the biggest influx of newcomers in the Northwest's history. It has gained a million and a half people. The population of Washington jumped from 1,700,000 to 2,500,000 between 1940 and 1950; Oregon went from 1,000,000 to 1,600,000. For the first time the Northwest, risen from the raw wilderness in a little more than a century, seemed to be within range of becoming an industrial dominion, rather than a mere outpost of eastern manufacturing and finance" (1).

We of the Pacific Northwest know only too well that we are merely "within range of *becoming* an industrial dominion," and we know also how long that range is. Our economy is still based primarily on mining, lumbering, agriculture and fishing, and though these are huge industries, they do not fully support the expanding population. Furthermore, we know that our natural resources are exhaustible. This latter is information which our forebears did not have, especially with regard to our stands of timber. Let us examine briefly then the growth of industry in the Northwest.

It was not until the end of the nineteenth century that the region became aware of its industrial potential. Statements to this effect began to appear in the several local newspapers of the area and the following item which appeared in the Oregonian August 21, 1880, had this to say: "Nothing short of the wonderful resources of the Northwest country would have kept up the rate of progress which the country has enjoyed."

In spite of this wealth of natural resources in timber, fish, minerals and agriculture, the Northwest has been dependent upon eastern manufacturers for finished goods and upon eastern capitalists for capital with which to buy eastern-made commodities. None the less, by the end of the nineteenth century industry had a good start in the region.

Growth Trends

Statistics show that this four-state area in 1899 had 4014 manufacturing establishments, providing production employment for 57,388 people, with an annual payroll of $32,082,000. Value added by

* Paper delivered Monday, June 19, 1950, at 58th Annual meeting of the Engineering College Research Council at the Annual Meeting of the ASEE, Seattle, Washington.

manufacturing was estimated to be $112,-313,000. By 1947 our manufacturing establishments had increased to 7801, employing 243,940 production workers, with an annual payroll of $693,687,000. Value added by manufacturing increased to $1,751,095,000. It is also interesting to note an increase in population during this same period of approximately 3,578,-260 (2).

Without a doubt research has played an important part in this growth, and has an even greater part to play in the future development of our tremendous industrial potential. At this point it might be well to take a look at some of the potential I am talking about, so let us consider an example in the field of minerals. The Bureau of Mines Mineral Yearbook for 1947, which I believe is the latest available, gives the value of minerals mined in the Pacific Northwest as $211,-638,000. At Pennslyvania State College, Professor Edward Steidle, Head of the School of Mineral Industries, worked out a formula for his own state, a ratio between actual mineral value and the total ultimate value through processing raw materials into products, which is generally accepted throughout the mining industry (3). If we apply this formula we find that in the Pacific Northwest we are realizing only the actual mineral value of $211,638,000 from a potential of $1,693,064,000.

Obviously then the possibility of increasing the wealth of the region merely by being able to process, fabricate and use the fruits of our own labor, quite conclusively indicates the need for even greater utilization of industrial research by industries of the Pacific Northwest.

Here in the state of Washington by act of the State Legislature, the Washington State Institute of Technology was established January 1, 1946 at the State College of Washington, Pullman, and the Division of Industrial Research was created at the same time as a subordinate branch to serve the people of the state by carrying on work in applied research for the benefit of local industry and to act as a training ground for advanced technology students. In cooperation with the Division of Industrial Services, it collects and disseminates technical information of value to industries. Work in virtually every field of technology, from bacteriology and food processing to hydraulics and electronics, is being carried on by the Division of Industrial Research.

Increased research activities are much in evidence here at the Engineering Experiment Station of the University of Washington, at Oregon State College, the University of Oregon, the University of Idaho, Montana State College and the several other institutions, totaling 14 State and Federal research organizations and 6 associations with research facilities. Industry itself maintains its own research laboratories in 23 privately owned companies, such as Boeing Aircraft Company, Weyerhaeuser Timber Company, Kaiser Aluminum & Chemical Company, and Crown Zellerbach Corporation, just to mention a few (4).

The organization of which I am Managing Engineer, the Inland Empire Industrial Research, Inc., is another facility here in the Northwest, implementing research in filling a gap between the research laboratory and industry, by presenting and assisting in the application of results of research towards the development of new products, the improvement of industrial processes, and the establishment of new industries to use our natural resources. Although privately organized, we are a nonprofit organization operating in the public interest, the membership benefiting only through the expanded development and increased prosperity of the area.

The instances in which industry has been aided by research in the Pacific Northwest are legion. To be more specific, I have gathered reports on a few definite problems that have been solved through research to the benefit of industry.

In the field of forest products, we find that through the efforts of the Oregon Forest Products Laboratory of Corvallis,

Oregon, a most notable example of the creation of an entirely new industry, as a direct result of research in their laboratory, is the inception of commercial production of wax from Douglas Fir bark by the Oregon Wood Chemical Company, Springfield, Oregon. This company has leased the Government-owned wood sugar alcohol plant erected during World War II. The production of wax from Douglas Fir bark will ultimately become a secondary product, because the company is committed by its lease to manufacture wood sugar and molasses from wood residue.

It goes without saying that research was responsible for the development of plywood, and a current illustration in this field in the Northwest is the development of exterior Douglas Fir plywood. The research work of the glue manufacturers in developing phenolic resin glues with setting temperatures which do not decrease the strength level for wood, made possible the production of exterior grades of plywood. Research also had to be carried on in the field of hot press design, in the auxiliary equipment and in some instances in properly tempering and conditioning the plywood, before it could be satisfactorily used. As a result Douglas Fir plywood today enjoys much wider markets and serves many purposes because its glued joints are entirely dependable, even under wet surface conditions. Its production has expanded tremendously.

Three plants in the Pacific Northwest now producing cardboard are a direct result of research, and with continued activities in this field it is expected that two or three more plants will be going into production on this type of product in the very near future.

One of the most outstanding results of research in the forest products field, assuring long range benefits, has come from a new processing accomplishment which is symbolized in the Springfield, Oregon, plant of the Weyerhaeuser Timber Company. Here is found the first large scale and permanent transition from the traditional wasteful one-product plant to one of complete utilization.

Research carried on by the Western Pine Association has resulted in:

The development of a clear, paintable, effective preservative "Permatol," which has led to greater and more efficient use of lumber.

Their development of a knot sealer WP–578 has increased the market for lower grade pine, and work on naval stores carried on in the laboratory was instrumental in the establishment of an extraction plant by Hercules at Klamath Falls.

The private laboratories of Arthur J. Norton, Seattle, Washington, developed a low temperature curing resin from resorcins which has proved valuable not only to the Pacific Northwest but also to other regions of the country in the woodworking industry. The Norton Company also helped in developing "Armafoam," a foamed-in-place resin for the aircraft industry.

The flotation studies of Dean Fahrenwald and his coworkers at the University of Idaho have resulted in machines and processes which have been widely used in the Pacific Northwest by industry. The most recent, a phosphate beneficiation process, has been adopted by the Anaconda Copper Mining Company. The fuming process, for the recovery of antimony and its separation from gold and silver ores, is being used in the new antimony smelter constructed by the Bradley Company at Stibnite, Idaho. This too was developed by Dean Fahrenwald and his coworkers, particularly Professor W. D. Wilde, of the Bureau of Mines and Geology at the University of Idaho.

That the research engineer can solve problems dealing even with such factors as the peculiar whims of a fish has been demonstrated by the success of the special fishways constructed in 1945 in the Frazer River area of British Columbia, the chief spawning grounds of the sockeye salmon. These fishways were based on models designed in the hydraulics laboratory of the University of Washing-

ton under the direction of Professor C. W. Harris (5).

A splendid piece of engineering research was done by the Northwest Experiment Station of the University of Washington, as a result of the failure of the Tacoma Narrows Bridge. A project was set up in the structural research laboratory for the purpose of developing a shape for the suspended structure which would be aerodynamically satisfactory, and reached what is confidently believed to be a successful conclusion in December 1945 (6).

These are but a few of the notable instances of the results of research for industry which have been selected not in order of importance, but rather as examples thought most apropos to the purpose of this discussion. I am sorry that time will not permit the review of more at this time.

From this brief summary of Pacific Northwest industrial research activities and their effect upon the industrial growth of the area, I am sure you will agree it has been clearly evident that research appears as an underlying network of strength in our progressive economic growth, and while not too tangible from a dollar and cents evaluation, it nevertheless has been a dynamic factor in the steady and successful conquering of a last frontier.

We do have several handicaps in our path to a more intensive manufacturing economy, one being the lack of population, which time alone can solve—and then only if we maintain a better and more stable plane of living so that living is better here than elsewhere. Another is our freight rate structure which provides primarily for outbound raw materials. This too can be corrected in time.

Along with these drawbacks, however, are the advantages gained in the large scale expansion of electric power which is taking place, so great in fact, it is now considered as a new resource. While low-cost power may be combined with minerals in important new activities, it would seem that its application to the industrial use of agricultural and forest products offers even more far-reaching possibilities. Research is the additional ingredient necessary if such possibilities are to be realized.

True, the Pacific Northwest is still dependent on making its living from the forests, the mines, the sea and the land, but better organized and increased industrial research activities, effectively applied, can and will provide this vital ingredient, contributing greatly to the development of our manufacturing and productive capacity, and leading to a more desirable balance in our regional economy.

REFERENCES

1. *Time* Magazine, page 23, May 15, 1950.
2. U. S. Department of Commerce.
3. Pennsylvania State College Bulletin, 1950—"Wanted Mineral Industries Colleges," page 109.
4. Research Laboratories of the Pacific Northwest—Raw Materials Survey, Portland, December 31, 1947.
5. "The Trend in Engineering," University of Washington, Vol. 1, No. 2, April 1949.
6. "The Trend in Engineering," University of Washington, Vol. 1, No. 1, Dec. 1948.

The Integration of Library Service with Teaching and Research, in Engineering School Libraries*

By JOHANNA E. ALLERDING
Librarian, Engineering Library, University of California, Los Angeles, California

There are three basic ways of acquiring knowledge: (1) learning from experience, by actually performing an experiment, by solving a problem, by observation, by doing or experiencing something; (2) learning from a more experienced person—a teacher, or a practicing engineer; (3) by reading the recorded experiences of others—whether in books, journals, reports or similar media. The first two have been discussed and studied at length. It is the third system that we wish to examine more closely, particularly the collection of printed materials, organized to provide maximum information, in other words, a library.

The present extent of technical and scientific literature is staggering. Since 1665, when the *Journal des Sçavans* and the *Philosophical Transactions* of the Royal Society were established, scientists, inventors and engineers have recorded their discoveries and findings in increasing numbers of journals. The publication of technical books can go back as far as ancient Egyptian days, when an engineer wrote a book on the design and construction of the Pyramids. At the present time it is estimated that each year some 15,000 useful scientific periodicals are published, containing about 750,000 articles. The *Engineering Index* annually lists approximately 50,000 articles in 1350 publications. Over 10,000 technical and scientific books pour from the presses each year. In opening the Royal Scientific Information Conference in London in 1948, the Chairman, Sir Edward Appleton, said:

> "This spate of scientific publications may, I think, be illustrated in the following way. If anyone set himself the task of merely reading—let alone trying to understand—all the journals of fundamental science published, and worked solidly at his task every day for a year, he would discover that at the end of that year he was already more than 10 years behind! If the same constant reader (I think we may well call him a constant reader) had included the technical literature as well, he would find himself about 100 years behind in his work after 12 months' effort!" †

With all of this recorded knowledge available, the engineering library becomes an important part of both the teaching and the research activities of engineering schools. The following discussion concerns primarily the relationship or integration of the library with these activities.

Building the Library Collection

A library is effective only insofar as it meets the needs of its clientele. The collection of books and journals should be adequate for the subjects taught and the

* Paper presented before the Engineering School Libraries Committee at the A.S.E.E. convention, University of Washington, Seattle, June 20, 1950.

† Royal Society of London, Scientific Information Conference, 1948. *Report and papers submitted.* London, Royal Society, 1948. p. 20.

research work being conducted. Let us examine first the building up of such a collection, assuming that sufficient funds are available.

The administration, whether the Dean, the director of research, or other person in charge of planning, should keep the librarian informed of anticipated courses of instruction and research projects, so that the necessary library materials can be acquired in advance of the needs. Entirely new subjects, such as ceramic engineering, might require additional funds to cover the field adequately in a reasonably short time. The librarian can learn a great deal of the future subject needs by sitting in on departmental and staff meetings where instructional course and research plans are discussed.

The research staff members should consult with the librarian early in the development of their project regarding the nature of the library materials which will probably be required. Research literature is often difficult to locate and obtain on short notice, resulting in delay to the project if insufficient time is allowed to acquire it in advance. This applies even to material which is to be borrowed on interlibrary loan. One should not wait until the last minute to request such material, as it may take considerable time to locate and borrow or reproduce a copy of the desired reference.

The faculty member or lecturer should learn enough about the limitations of the library's resources to plan his reading and report assignments accordingly. He should know how long it takes to acquire new titles and process them for use. Lists of his collateral reading assignments should be discussed with the librarian well in advance of the assignments, so that titles not in the collection can be purchased and prepared in time for the students to have access to them when assignments are made. The instructor should also consider and inform the librarian as to the number of students who will be needing the material, and if the material will be used for a brief time, for one semester only, or for several semesters. This has a direct bearing on the number of copies which the library will wish to purchase.

The entire engineering staff should become familiar with the nature of the library collection, especially its weaknesses, and recommend both new and basic older books and journals for acquisition. This can be done through a library committee or by direct suggestion to the librarian. Librarians are particularly pleased to receive recommendations of obscure but valuable titles which are not listed or reviewed in ordinary channels.

Finally, donations of personal copies of books and journals no longer needed by the staff are welcome as a means of filling in gaps, replacing worn-out or lost copies, or as a medium of duplicate exchange with other libraries. It is therefore through foresight and awareness of needs that a library can be built up to meet the demands of students, faculty and research staff.

Library Service

When a suitable collection has been acquired, the means of making it available is of primary importance. Librarians are no longer just custodians of books, but serve as a liaison between the collection and the readers. A certain amount of organization and planning is essential.

A good card catalog of the engineering library collection is the first requirement. It should be possible to locate a book from several approaches, such as by author, subject or sponsoring society. Even if the engineering library's holdings are represented in the general catalog of the institution, it is important that the departmental library have an adequate catalog which is not only immediately accessible, but also tailor-made for the needs of the engineering clientele. By this is meant that extra entries are made for societies responsible for a publication (such as the American Society of Mechanical Engineers), the series title and number of a book published as part of a

series (such as the Massachusetts Institute of Technology, Radiation Laboratory Series), and specific subject headings which reflect the terminology of the courses and research work. For example, a professor teaching courses in ceramic engineering would not look under POTTERY for books on ceramics as an engineering subject. Nor would one wish to look through dozens or hundreds of cards filed under ELECTRIC ENGINEERING or MATHEMATICS to find a book on the mathematics of electrical engineering.

Arrangement of the collection by function makes it easier to use the library resources. All of the indexes to periodical literature should be grouped in one area, regardless of the particular subject classification number. This will not only facilitate literature searching but call attention to indexes which the library user may not realize exist. Reference books, such as handbooks, dictionaires and directories, should also be grouped in one area as an aid to finding information readily. The classification number of the *Handbook of Chemistry and Physics* may be quite different from the *Chemical Engineers' Handbook,* but if they are both located in a compact reference collection, they will both be found and used for the same question. The assigned reading material is best kept under library control, as distinct from "open stacks," to prevent its disappearance or at least monopoly on the part of selfish students. In this connection it is well to emphasize that instructors should always notify the librarian about assignments involving library materials before the assignments are made. This gives the librarian a chance to call in books that are charged out, order material not in the library and put all of the items under control for restricted use. It is even desirable for the librarian to have a copy of all assignments made to students, whether or not specific titles are recommended, to the end that the librarian will be prepared to help the students find the necessary information in the library collection.

Since no library will be able to accumulate every item which will ever be requested, there will be occasions when the librarian will be asked to borrow material on interlibrary loan. The staff members should keep in mind that borrowing is asking a favor of the loaning library; it is not a right which can be demanded. The costs of mailing are usually paid by the borrowing library. It takes time to identify a requested item, to write and request if from a library that may have it, and for them to find it in their collection, wrap and mail it and prepare the necessary records. In addition, such packages do not usually go by first-class mail, so that the transit time is often quite a bit longer than it would take a letter. All in all, the whole transaction is apt to take more time than one would expect. The engineering staff should observe the following points in making use of inter-library loan facilities:

1. Give the librarian as complete a reference as can be ascertained from the source.
2. Allow sufficient time for the material to be found and received.
3. Use borrowed material quickly and return it promptly.

An engineering library, such as the type we are discussing, is intended to serve a variety of groups—students, faculty, research staff, and possibly local industry. Every such library user should therefore consider the collection as available to and used by all the other potential readers. This means that material should not be kept in one's office or laboratory for months or even years on end. Such "office collections," made up of library books, defeat the purposes of the library as a centralized, controlled and coordinated service for all groups. This is not to say that there is no place for office collections. If needed frequently, these books should be acquired personally or jointly with fellow workers, through special funds or through duplication of material in the library. Such duplica-

tion should not be done at the expense of the building up of the library's collection.

Most laboratory research will benefit from a thorough study of the published literature which may have a bearing on the subject. Such a literature survey may turn up valuable data, thus preventing useless duplication or poorly planned investigations. It will provide contact with new ideas, give a historical perspective and add breadth to one's present knowledge of a subject field. The library staff can be of assistance to the research staff in making a preliminary search through indexes, abstracting journals, handbooks and data books, bibliographies and similar reference tools, listing and locating suitable references for the research staff to study with more critical scrutiny. The librarian can also help in finding specific data, since he is usually more familiar with a great variety of reference books.

The Library as a Teaching Tool

The engineering librarian should know enough about the technical literature, indexes and resources to be able to help both students and faculty in locating a variety of material on requested topics. One aspect of this is the teaching of the scope of technical literature and the use of the library. This can be done either through a formal course on the subject or through one or more lectures in other courses, as Report Writing.

Courses on the literature of a subject are more common in other fields, notably chemistry. Relatively little has been done along these lines in engineering schools. A step in this direction is the required one-unit course in Engineering Library Technique, offered in the Columbia University School of Engineering, and taught by the engineering librarian, William S. Budington. The 1949/50 Announcement of the School states (p. 40):

"All undergraduate students are required to become familiar with the more important scientific reference works and the use of various indexes and card catalogues which are essential to the intelligent use of modern library facilities."

At the University of California at Los Angeles a course on "Technical Literature and Library Orientation" has been offered in the Engineering Extension Division. Due to several reasons—evening class, extra fees, not a required course—it has not drawn many engineering students. It is hoped that such courses will be established within the regular engineering curriculum of many engineering schools, either as required or elective one or two unit courses.

The departmental library also serves as an informal teacher by exposing the students more directly to the books and journals than is usually possible in a large, closed-stack library. The students can go directly to the shelves and browse through the collection, finding books they would not even have thought of looking for in the card catalog. This is where the humanistic-social aspect of engineering education can be brought to the students' attention in an inviting way. The engineering library should therefore provide a variety of books on applied psychology, economics, history of science and civilization, biographies of engineers and scientists, scientific classics, and even some good fiction with a scientific or technical background.

From this analysis we can conclude that, if the teaching and research staff will keep the librarian informed of its plans and projects, the library staff can build a suitable collection of library materials and organize it for effective use. The librarian can and should take an aggressive part in assisting both students and staff in finding printed material on specific subjects and in making full use of the vast array of technical and related literature. Through such cooperation the library can become an important and integrated part of the teaching and research program of engineering schools.

Let's Be a High School Freshman*

By W. S. EVANS
Head, Department of Civil Engineering, University of Maine

At the Annual Meeting two years ago we were told that industry was willing to cooperate with us to the fullest degree, and I am frank to confess that I could not see how we could make use of this offer in a coordinated and efficient manner. I have a better idea now.

Last year, representatives of prominent secondary schools told us that there was little hope that, by and large, our students would be better prepared in the future. This was not due to lack of desire on the part of school officials or to lack of ability but rather to the nature of the problem. Briefly, the type of secondary school education which we can expect will be such that not only the average high school student may master it, but that the majority of such students may feel that they have accomplished something worthwhile when they have received a high school diploma, and that they may be eager to stay on in high school to achieve that end.

We shall see mathematics more interesting rather than effective, we shall see physics and chemistry more descriptive rather than mathematical, we shall see more time devoted to the vocational subjects rather than to disciplinary drill in and mastery of those subjects which are more basic to a college education. While these tendencies which you and I have seen develop during the last twenty-five years are more or less general, there are opportunities in many schools for excellent college preparation. Of this there is no doubt and, except for the smaller country school, of which my own state has hundreds, if a student knew when he entered high school as a freshmen, that four years later he would be attempting to gain admission to an engineering school, he could do much to bolster his preparation. On the other hand, if many students who enter high school with definite plans to enter an engineering school knew more about the intellectual requirements necessary to successfully pursue an engineering education, if they knew that to take the engineering curriculum, many of them would have to sacrifice the pleasures and prestige which they might otherwise derive from extra curricula activities, they might wisely elect to try some other field.

The high schools have a tremendous job to keep our boys and girls in school until they are eighteen, to say nothing of attempting to give particular groups special attention. Juvenile delinquency can be reduced and society in general may profit if our youth can be held in school through high school and thus have their efforts directed toward useful ends rather than permit them to hang around street corners and disreputable meeting places, indoors and out. Since the percentage of high school graduates who go to technical institutions is very small, say between one and two percent of the total, and perhaps 10% or 15% of the total going to institutions of higher learning, we can hardly expect even the larger school to carry special facilities for the small group. Let us give the secondary

* Presented at the Annual A.S.E.E. Meeting in Seattle, Washington, June 23, 1950, before the Committee on Secondary School Relations.

school system due credit for doing a fine job with insufficient staff and funds and see what we can do to help them. Possibly one way is through vocational guidance in any or all of several different ways.

What the High School Students Think

When we think of vocational guidance we usually think of the many books and hundreds of articles written on this subject. If we talk with the people for whom these books were intended, and who should read them, we will find that very few students who might have benefited by reading them have done so. This is especially true for the full size books. More have read the pamphlets, so perhaps we might conclude that the smaller the book, the more people read it. This may or may not be true, but as many questions could be asked concerning the best way to get at this problem of guidance, it was decided to ask representative groups of students just what has helped them most to wisely choose their vocation and prepare for it. I want to offer my sincere appreciation to Dean Roy M. Green of the University of Nebraska, Dean Everett D. Howe of the University of California, Dr. Ralph J. Smith of San Jose State College, Professor H. H. Hill of the University of Oklahoma, Professor Karl N. Hendrickson of the University of Massachusetts, Professor W. Irwin Short of the University of Pittsburgh, Professor E. O. McLean of Rose Polytechnic Institute, Professor W. M. Lansford of the University of Illinois, and Professor L. O. Stewart of Iowa State College, who selected a group of students in their respective institutions to write me personal letters expressing their ideas as to what, in their high school days, would have helped them most to wisely plan their life's work. The specific request was to write me a short letter in answer to the following questions:

1. Did they have adequate guidance during their high school course, as to:

A. What type of work to pursue?

B. Whether or not they should go to college?
   1. What course to take?
   2. How to prepare for that course?

2. What type of information helped them most, during their high school days, to plan their later life?

3. What suggestions do they have as to how high school students could be helped most in planning their later life?

It was further stated that it was not necessary to answer these questions as all that was wanted was a frank statement as to whether they had received adequate guidance in high school, and suggestions that might be used as a guide in attempting to help future students. The results were more than pleasing.

Many of the letters I would like to read in whole or in part, and I would like to thank each boy personally who wrote to me, but there is not time for the former, and I've attempted to do the latter through the faculty member who secured their aid. I can list some very definite patterns as many of the letters were strikingly similar even though they came from opposite ends of the country. The following statements are well substantiated by many replies:

1. Guidance is needed most during the first and second years of high school.

2. Although a few schools have well organized guidance programs and are doing much to help their students, there were very few replies which told of adequate guidance throughout the four years.

3. Several mentioned the need of a good testing program with follow-up conferences throughout the four years.

4. From one set of twelve replies, five mentioned the desirability of having men from industry speak to the students. Several others mentioned the need for information which could well be given in this way.

5. Although the larger schools have better guidance programs, there is much to indicate that students in the smaller schools and smaller towns get much more

personal attention that is greatly appreciated.

6. Several mentioned the help received from university bulletins. If they were really helped by the ordinary university bulletin, it strains the imagination to think what could be accomplished if engineering schools were permitted to send out information designed for guidance.

7. As would be expected, individual conferences are much more desirable and helpful than mass instruction.

8. Many students feel their advisers are not well informed especially on technical matters.

9. Good guidance or lack of it seems to characterize no particular sections of the country.

10. There is some indication at least that other fields are more talked about or talked up more than engineering.

The above items could be increased by a careful study of the letters received but these ten clearly indicate that (1) there is an unquestionable need for more and better guidance, and (2) the best time for it is early in the high school course, that is, during the first or second year.

What is Being Done?

Along with the attempt to find out what was needed, an effort was made to gather information on what was being done. Letters were sent to all the sections of A.S.E.E. and in all cases the answer was the same, "That nothing was being done." Some work is being done by the service clubs, the most outstanding of which appears to be through scholarships granted by at least one club for the benefit of vocational guidance teachers, and through the organization of guidance groups throughout the country. These efforts are commendable and undoubtedly helped many boys to wisely enter or keep away from the engineering profession. Although A.S.E.E. might secure some aid through the service clubs, the latter's efforts alone cannot go far toward the solution of our problems.

Some engineer clubs are also doing extremely extensive and valuable work in offering educational programs for vocational guidance teachers. Engineer clubs in several cities, especially the larger cities, are organized to give the kind of guidance necessary. Whether or not this service reaches the right student at the right time is not known, but they are still filling a much needed gap. From the city that has the best organized and most effective program comes the statement that in spite of all they are doing, the lack of information and the amount of misinformation is still tremendous.

The engineering societies are doing the job as they see it and here again much valuable work is being done. Probably the most finely directed effort is being made by E.C.P.D. through its publications. "Engineering as a Career," "Manual for Committees of Engineers Who Aid Young Men Interested in Engineering Education and in the Engineering Profession," and its latest, "The Engineer and His Work." These are all fine works, but in the many letters I received, only one reference was made to literature, other than university bulletins, which had been helpful. If this ratio of 1% is truly representative of those who are helped by reading, what hopes are there that anything published to date will, to any measurable degree, solve our problem?

Some institutions such as Texas A. & M. put out what should be a very effective piece of work. It would be difficult for state universities in general to put out similar literature concerning engineering alone, and a similar treatment of the whole university would be too long to read. This type of effort should be kept up wherever possible.

Industry's Viewpoint

Some industries are doing a great deal to promote engineering interests. Some ten or more years ago the Johns-Manville Corporation, realizing that the young men in their dealer organizations were not of such a type as could assimilate the training which they were offering throughout the country, set out to promote cur-

ricula in light building construction wherever there was an opportunity. Needless to say, such curricula would be useless unless young men could be attracted to them, so they published an attractive brochure listing the opportunities in the light building field and the institutions offering the curricula. This was distributed to high schools and other educational institutions throughout the country. I know this was effective since, as one of the schools listed in this brochure, we have received inquiries from high school students and parents over the whole eastern part of our land. As far as I know Johns-Manville has not employed a single graduate from my institution, but nevertheless, I feel they rendered the building industry and engineering in general a great service by drawing attention to the possibilities of this field. This type of publicity is effective.

Let's look at another industry, United States Steel. This industry is looking forward to the time when there may be a shortage of trained personnel. They plan to forestall this possibility by drawing attention to the steel industry through their brochure "Steel Making in America." This is aimed not at high school or college students but at eighth graders, with the hopes that others may read it. The brochure appears somewhat heavy and possibly too lengthy for their purpose, but it is attractive and the idea is excellent. I hope it will accomplish the purpose for which it was intended. Many other similar examples could be found, but the above two are sufficient to illustrate a means of partially solving this problem of guidance.

I do not want to give the impression for a single moment that present efforts toward vocational guidance at the high school level are ineffective or useless. What the service clubs, the engineering societies, the colleges and industry are doing is excellent but we need more of it. Vocational guidance in the high schools is making tremendous strides, but I doubt if engineering and technical work is receiving its share of attention. As evidence of this, we have reports from all sides that high school seniors are being advised to keep away from technical schools because there are no opportunities in the technical field. If we are doing our job, these rumors could not persist. I said, "If we were doing our job" but is it our job to do?

If the engineering schools were in a money making business, then attracting students to our door would definitely be our job. If our job were to render a service to American youth by giving as many of them a technical education as possible, then it still would be our job and ours alone. As I see the situation, we are rendering a service to our youth by giving them a technical education only insofar as there is an opportunity for them in our industrial or business world. We are rendering a service to industry and business only insofar as we can provide them with well trained young men. The common factor here is industry. The type of young men we train and the number we train is important to industry, not to us nor to the young men, assuming they could find equal opportunities elsewhere. Industry wants the young men, it's our job to supply them and the secondary school's job to prepare them for us. If the gap between high school and college is too great, and many students think it is, either the secondary schools must go higher or the colleges must start lower. This is getting off our subject, but for the secondary schools to do their best in preparing students for us, they must know what the students want as early as possible.

For the student to make a selection is not an easy problem. He has no experience, little background and little or no knowledge of what it is all about. It's hardly possible for him to answer a questionnaire as he has no knowledge upon which to base a comparison. It appears that two steps should be taken:

1. Determine a student's aptitudes as early as possible.

2. See that he gets as much information about as many things in a form he can understand as early as possible.

The high schools must develop the means of administering and interpreting the results of aptitude tests. Industry is missing an opportunity if it overlooks a single means of getting information to our young boys and girls. Many industries are spending large amounts to inform the public of their products, their size, their labor, and other policies. It would appear that they might do well to also inform our youth of the opportunities for gainful employment which they can offer to well trained young men and women. There are great opportunities for our youth upon whom the success of our industrial future depends. Industry is willing and possibly we can help show them the way.

In addition, what can we do? First, we, as members of our separate professions, Civil, Electrical, Mechanical, etc., can stress, within our societies, the need for early guidance of our youth. Second, we, as members of A.S.E.E., can invite high school teachers to our section meetings and discuss these problems with them. Their teachers are willing, their guidance directors are willing, but they know too little of opportunities and requirements in technical fields. We can hammer on this subject at every opportunity in our own towns and our own states. Let's not leave the job up to other agencies; we should do it ourselves.

A T-Section Transmission Line for Laboratory Work

By L. A. WARE, *Professor of Electrical Engineering* and E. M. LONSDALE, *Assistant Professor of Electrical Engineering*

State University of Iowa

In many schools at the present time, courses in Communication Transmission are given as part of the undergraduate curriculum. Instruction in this field is greatly facilitated by concurrent laboratory work containing several experiments on the properties of transmission lines. Many experiments may be quite conveniently conducted at audio frequencies using a lumped circuit artificial transmission line thereby eliminating many of the difficulties attendant upon radio frequency procedures. The purpose of this paper is to describe such a low-frequency line which has been in use at SUI for several years by the authors in the first course in transmission theory.

Physical and Electrical Requirements

A line, to be used for laboratory work, should, first of all, meet certain requirements of a purely practical nature. These are five in number:

1. The line should be as compact physically as possible to facilitate handling and storage.
2. It should include a reasonable number of sections so that curves plotted vs. length in sections will have a sufficient number of points.
3. It should operate at a low frequency, perhaps between 500 and 10,000 cps.
4. The arrangement of switches and terminals should provide flexibility so that a number of experiments can be performed with the same line without too much rearrangement of equipment.
5. It should be of the unbalanced-to-ground type in order that the standard testing and measuring instruments, CRO, VTM, etc., function properly.

There are also some electrical requirements which aim at obtaining well proportioned curves. In other words, the line should have values of α, the attenuation constant, and β, the phase constant, which will produce at least a 4-to-1 variation in the voltage over the length of the line. It was considered that the use of convenient values of α and β was of more importance than the representation of an actual line. Thus no attempt was made to set L/C at the value of any existing line. The unit of length is the section and no reference is made to equivalent miles, meters, etc. The line to be described has the following constants at 1000 cps.

$$\alpha = 0.112 \text{ neper/section}$$
$$\beta = 0.382 \text{ rad/section}$$
$$Z_{oT} = R - j\frac{1}{C\omega}$$

where $R = 199$ ohms and $C = 2.88$ mfd. The parameters of the line which result in the above constants were selected so that each T-section consisted of two coils and one condenser without an additional resistor. The values of these parameters are as follows:

$R = 44.5$ ohms (contained in two coils)
$L = 11.2$ mh. (contained in two coils)
$C = 0.3$ mfd.
$G = 0$

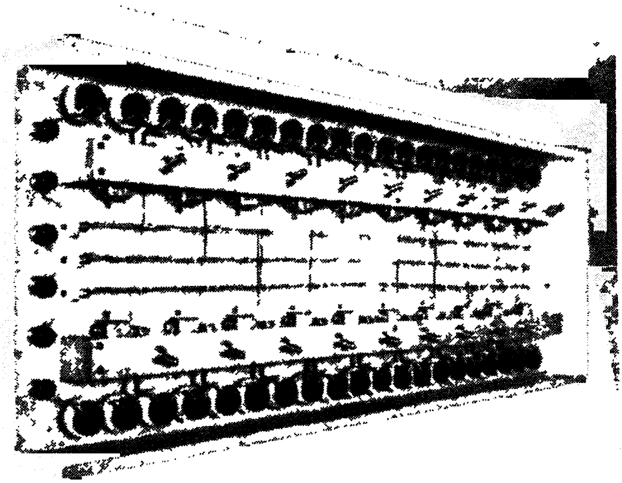


FIG. 1. View of assembled line.

The number of sections necessary now depends upon the above constants and the maximum phase shift desired. Since it was convenient to have a line of well over one wavelength in length, twenty sections were used. The general appearance of the line is as shown in Fig. 1.

While this line was constructed for voltage measurements only, it is possible to make use of a current-measuring VTM if desired.

Description of the Line

As shown in Fig. 1, there are twenty sections, each one of which is made up of two coils and one condenser as represented in Fig. 2. The inductances are

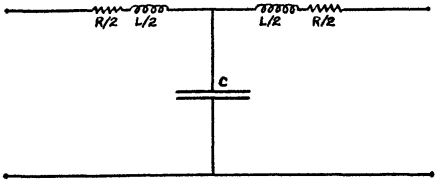


FIG. 2. Components of one T-section.
L = 11.2 mh., C = 0.3 mfd., R = 44.5 ohms.

air-core coils of about an inch in diameter and the condensers measure about ½″ × ½″ × ¾″. The overall length of one section including switches is 3″. The line is doubled back as shown in Fig. 1 resulting in an overall length of 2′ 10″ including the terminals, etc. The width is one foot. The line is thus small enough to be used conveniently in the average laboratory, and this size constitutes the principal advantage of this line over those previously in use.

The wiring diagram of the line is given in Fig. 3 where only the first and last few sections are shown. (It should be noted that the photograph of Fig. 1 is of an earlier model which does not agree with the switching of the 20th section as indicated in Fig. 3.) Toggle switches are used between sections to facilitate the necessary changes in the line during an experiment. Further, the use of toggle switches increases the reliability of the line since the contacts are self-cleaning and reasonably trouble free.

Referring now to the wiring diagram of Fig. 3, it is seen that provision is made for easily connecting either terminating impedances or voltage-measuring instru-

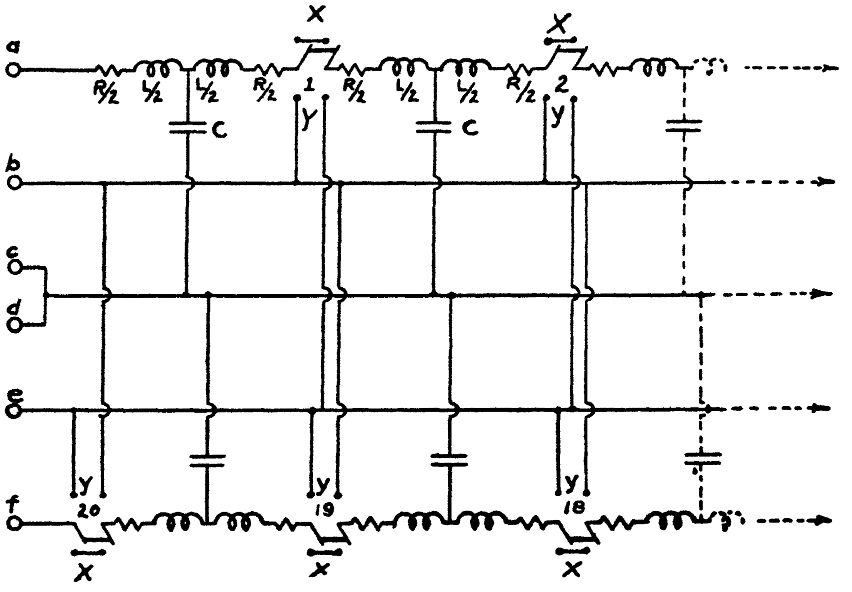


FIG 3 Wiring diagram of the artificial transmission line

ments into the line at any point, and also that any termination may be connected to the end of the line The input terminals are a and c, c being the grounded side of the line and common with the terminal d The output terminals are d and f, across which any termination may be connected Connection of voltage-measuring instruments at any point along the line such as at the end of section 2 is accomplished as follows Suppose that it is desired to make a series of readings of voltage along the line when terminated in a general impedance Z_r First, the termination, Z_r, is connected to terminals d and f The input terminals a and c are connected to an oscillator and a switch by which the reference input voltage, V_s, may be obtained using a VTM or CRO Refer to Fig 4 The section switches of the line are all thrown to position x in Fig 3, except for the one after section 2 This is thrown to position y and it is seen that this extends the line from a through the first two sections, then back to terminal b from which there is a connection to e feeding back to the switch of section 2 and into the remainder of the line The VTM, or CRO, is connected across b-c

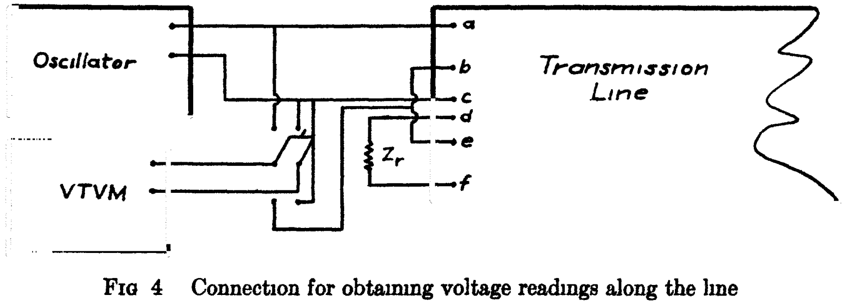


FIG 4 Connection for obtaining voltage readings along the line

also, thus providing a convenient method of comparing the voltage at the output of section 2, V_2, with the input voltage, V_s. By setting section switch 2 to the side x and setting the switch for section 3 to y the voltage V_3 is determined, etc.

The terminals are so arranged that it is convenient to carry out the procedures for a number of the simpler experiments quite easily. All communication laboratories conduct a number of such experiments and the application of this line will be immediately evident.

The usefulness of the line may be extended by providing a built-in characteristic impedance, Z_0, with its associated switches, and by arranging additional resistance and capacitance which can be switched into each section in order to obtain different values of α and β.

// THE T-SQUARE PAGE

Officers
R. S. Paffenbarger, *Chairman*
O. W. Potter
T. T. Aakhus
C. J. Vierck
J. S. Rising
H. E. Grant

Devoted to the Interests of Engineering Drawing

J. Gerardi, *Editor*
University of Detroit

Officers
I. L. Hill
J. G. McGuire
W. E. Street
C. E. Rowe
H. C. Spencer
W. J. Luzadder

New SAE Automotive Drafting Standards Aim at Unified Industry Practice

The new SAE Automotive Drafting Standards, which are the fruit of more than three years labor of over 100 engineers, promise three chief gains:

1. A uniformity of drafting instructions which will enable students and graduates to fit readily into the engineering departments of the automotive industry.
2. Uniformity in drawing practices within the industry which would simplify supplier-purchaser relationships.
3. Improvement in military production. Heretofore, there has been much loss of time, money, etc., because of inadequate national and international drawing standards. The SAE is making every attempt to better these conditions.

Automotive men have long felt the need for standard drawing methods for both inter and intra plant purposes. Time lost by vendors and buyers because of drawing misinterpretation has proved costly and irksome. At times, even factory men of given companies have found difficulties understanding the drawings of their own engineering departments. Serious as this may be in peacetime, these delays are even more critical during war production. Realizing that these impediments to production efficiency could be largely minimized, the Society of Automotive Engineers appointed a committee to develop for publication, drafting standards for the automotive industries. The Drawing Division of the American Society for Engineering Education is represented by Prof. J. Gerardi, Assistant Dean, College of Engineering, University of Detroit, and Prof. Ralph T. Northrup, Head, Engineering Drawing Department, Wayne University. Industry is represented by companies such as Chrysler Corporation, Ford Motor Company, Bendix Aviation Corporation, International Harvester, etc.

To obtain its objectives, the Steering Committee has selected the most acceptable drafting practices, consulting with draftsmen and engineers in all phases of the ground vehicle industry. The Standards are divided into two main parts—Fundamentals of Automotive Drafting Practice (Part I) and Specific SAE Automotive Drafting Standards (Part II). The Automotive Drafting Fundamentals (Part I) reflect the industry's practice on basic drafting elements. The rudiments of lettering, sectioning, projections, and dimensioning are shown in detail. The two-place decimal dimensioning system, which many automotive manufacturers are now using, also is presented. A chapter is devoted to screw threads. Methods of designating and drawing the new Unified Threads (American, British and Canadian) are among the items covered here. The drafting fundamentals section also includes chapters on drawing revisions, layout, and checking.

The Committee is convinced that the publication of the section on drafting fundamentals will be a useful reference for teaching drawing in colleges and technical schools. It feels that this publication can supplement basic drafting texts in preparing engineers for the automotive and allied industries.

Part II of the SAE Automotive Drafting Standards delineates procedures in more specific areas. It shows how to prepare drawings for castings, die castings, springs, powdered metal parts, and chassis frames, and how to specify surface finish. Expansion of this section is contemplated for the future.

Anyone who may wish further information regarding these standards may write to R. C. Sackett, 808 New Center Building, Detroit 2, Michigan, or the SAE Special Publications Department, 29 West 39th Street, New York 18, New York.

W. A. Siler,
Chairman,
SAE Drawing Standards Committee

Minutes of Executive Board Meeting

A meeting of the Executive Board of the ASEE was held on Wednesday, November 15, 1950, at the Carlton Hotel, Washington, D. C. Those present were: F. M. Dawson, *President,* H. H. Armsby, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, M. Wiltberger; and (by invitation), T. Saville, J. McKeon, and H. R. Beatty.

Report of the Secretary

The Secretary stated that the Society has received notice that the rates for publishing the JOURNAL OF ENGINEERING EDUCATION would be increased approximately eight per cent. This will add about $1700 to the publication costs, assuming that the number of papers published is not diminished.

Report of the Treasurer

The Treasurer reported on the Internal Revenue Bureau ruling regarding legislative activities of non-profit corporations. The following is an excerpt of Section 29.101(6).1. Internal Revenue Code. The principal provision is:

"No substantial part of (non-profit corporation) activities may be devoted to carrying on propaganda or otherwise attempting to influence legislation. An organization for propaganda purposes has been distinguished from an educational organization as one organized to benefit and assist the aims of one class against another, to encourage the dissemination of ideas in support of one doctrine as opposed to another, *to the profit of one class, and to the detriment perhaps of another.*"

Lamme Medal

Mr. Skelley also reported on his investigation of alternative plans for reducing the cost of the Lamme Medal in order to bring the cost of the Award in line with the income. The Society has been receiving $116 each year from the Lamme Medal account, and the cost of the Medal alone is now approximately $167 per year. The cost of the Medal could be reduced either by reducing the size of the Medal (retaining the 10 kt. gold content), or by using a rolled gold Medal of the present size. Reduction of the size of the Medal would entail a cost of $150 for new dies. The Board voted to defer the decision until the March meeting, pending examination of the Lamme deed.

Reports of the Vice-Presidents

Vice-President Armsby reported that Texas A. & M. College had submitted a satisfactory Constitution for a Branch of the Society. The Executive Board voted approval of this Branch.

Vice-President Armsby reported that two Subcommittees of the Committee on Atomic Energy Conferences had been formed and had planned their meetings.

Vice-President Armsby reported that T. Saville, S. C. Hollister, and himself had represented the Society at a meeting of the Engineering Manpower Committee held by the Engineers' Joint Council. This Committee was formed at the request of the N.S.R.B. in order to provide recommendations from the engineering profession for national policies relating to the utilization of engineering manpower.

Vice-President Grinter presented the request from the First National Congress of Applied Mechanics for ASEE sponsorship and financial assistance. The ASEE voted to co-sponsor the Mechanics Congress and voted to allocate up to $50 to the expense of the meeting.

Vice-President Grinter stated that a question had arisen as to whether Summer Schools might be sponsored by Sections

of the Society as well as Divisions. The Board voted to restrict Summer Schools to the subject matter Divisions of the Society. However, there was no objection to Sections holding a Conference on Improvement of Teaching if they so desire.

Vice-President Grinter mentioned that President Heald had suggested the possibility of appointing a Washington representative to maintain liaison with both legislative and operation developments dealing with engineering education, manpower, and research during the state of emergency. No decision was reached on this proposal.

Vice-President Terman reported that the ECAC had cooperated with the ECRC in the preparation of programs for the meeting in Washington, D. C. on November 16–17, 1950. These meetings consisted of panel discussions with representatives from engineering education and the government, dealing with the subjects of: (1) Technical Manpower Requirements and Controls, (2) Emergency Educational Planning, and (3) Utilization of Research Faculties and Facilities.

Vice-President Rosselot reported that the ECRC was considering the preparation of a survey of research personnel and facilities in engineering colleges. He pointed out that similar surveys were being considered by (1) U. S. Office of Education, (2) Research and Development Board, (3) American Council on Education, and (4) The Department of Commerce. The ECRC Subcommittee on Cooperation with Military Agencies has concluded a tentative agreement with the Research and Development Board for this survey. An attempt will be made to prepare a single survey which would serve the needs of all government agencies.

Educational Testing Service

Professor H. R. Beatty reported that the use of the engineering tests provided by the Educational Testing Service had declined sharply and that this portion of the testing program was operating with an annual deficit. He stated that the Educational Testing Service was considering a further reduction in the volume of the tests and also, the possibility of selling the tests outright to engineering colleges. The Executive Board asked the ECAC to assist Professor Beatty in a survey to determine which person in each of the engineering colleges is responsible for engineering testing and also, to bring to the attention of the engineering deans and the persons in charge of testing, information about the E.T.S. tests.

ECPD Charter Revision

No action was taken on the proposal of ECPD to amend its charter, pending receipt of later revisions to this amendment.

1953 Annual Meeting

The Secretary reported that invitations had been received from Oklahoma A. & M. College, the University of Florida, Clemson College, Pennsylvania State College, Iowa State College, the University of Illinois, and Case Institute-Fenn College in Cleveland. The University of Illinois will hold its fiftieth anniversary of engineering education in 1953 and has suggested that this be given consideration in the selection. No action was taken.

Fontana Conference Resolution

A Resolution by the Southeast Section requesting that the Society appoint a Committee to work with agencies of the federal government in developing suitable programs for (1) the proper deferment and utilization of technical manpower (including engineering student deferment) and, (2) the planning of emergency educational programs. It was pointed out that the Coordinating Committee on Relations with the Federal Government was appointed to coordinate the Committees of the Society which are working with the government agencies on these problems, and that the meetings of the ECAC and ECRC in Washington, D. C., were directed to the specific objectives set forth by the Southeast Section Resolution. Also, a dinner meeting of represen-

tatives from the government and members of the ASEE Coordinating Committee on Relations with the Federal Government, had been previously planned to discuss informally the same problems, which were contained in the Resolution of the Southeast Section.

Junior College Committee

The Junior College Committee of the Society has requested that the Executive Board and General Council consider the possibility of granting Division status to the Committee. The Executive Board voted to recommend to the Council that this matter be given consideration at the June meeting of the Council.

Engineering Education Mission to Japan

A request by the U. S. Army for the names of persons who might comprise a mission to advise Japanese educators on problems associated with engineering education, was discussed. The Executive Board decided to circularize the deans of engineering colleges to obtain names of persons qualified and available for such a mission.

Certificate of Authority

The Society has applied for permission to operate as a non-profit corporation in the State of Illinois. The application was rejected because the title of the Society was similar to that of the American Society of Industrial Engineers which is a non-profit Illinois corporation. The Treasurer volunteered to obtain legal advice from his firm's legal consultants.

Amendments to the Constitution and By-Laws

Several amendments to the Constitution which were favorably recommended by the Committee on Constitution and By-Laws were considered. The Executive Board voted to refer these Constitutional amendments to the three Councils of the Society for consideration at their next meetings.

Additional Agenda Items

The following items were considered by the Executive Board and recommendations made to the General Council. These recommendations are summarized in the minutes of the General Council meeting.

1. Annual Meeting—Dates and General Sessions.
2. ECPD Program of Professional Development.
3. Membership Status of Servicemen.
4. Teaching Aids Committee.
5. James H. McGraw Award Presentation.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Minutes of General Council Meeting

A meeting of the General Council of the ASEE was held on Thursday, November 16, 1950, in the Carlton Hotel, Washington, D. C. Those present were: F. M. Dawson, H. H. Armsby, L. E. Grinter, G. A. Rosselot, F. E. Terman, C. L. Skelley, A. B. Bronwell, T. Saville, C. J. Freund, H. W. Barlow, H. R. Beatty, C. E. Bennett, K. L. Holderman, H. K. Justice, J. D. Long (substitute), J. C. McKeon, M. B. Robinson, E. A. Walker, M. T. Ayers, R. D. Landon, E. R. McKee, L. G. Miller, K. F. Wendt, R. Z. Williams, M. Wiltberger, Guests: A. G. Conrad, Pemberton Johnson, J. I. Mattill, C. V. O. Terwilliger.

Reports of Officers of the Society

The reports of the Vice-Presidents, Treasurer, and Secretary are summarized in the minutes of the Executive Board meeting of November 15. A motion to accept the reports was passed.

Amendments to Constitution and By-Laws

Certain Amendments to the Constitution authorizing the formation of "affiliate branches" of the Society in Technical Institutes, which had been favorably recommended by the Committee on Constitution and By-Laws, were considered. It was voted to refer these amendments to the ECAC, the ECRC, and to the General Council at its June meeting. These Amendments will then be submitted to the Society membership for vote in conformity with Constitutional provisions.

The following Amendment, as an addition to the By-Laws of the Society, was favorably voted by the General Council. This Amendment will be voted upon by the ECAC and the ECRC. The Amendment formalizes the operating procedures which have been practiced by the Society offices in the past. It will then be presented at a regular meeting of the Society for official vote.

"The Secretary shall receive, disburse and account for all funds of the Society; shall be responsible for all properties, including securities; shall submit quarterly financial statements to the Executive Board; and shall be responsible for having the books audited annually. The Treasurer shall examine all monthly bank statements and the final audit, and shall be official adviser to the Executive Board on all financial matters. All disbursements shall be made in accordance with the approved budget or a direct appropriation authorized by the Executive Board for a special purpose.

All checks and vouchers shall be cosigned by the Secretary and the Treasurer of the Society. In the event of the absence or incapacity of the Secretary, the Assistant Secretary is authorized to cosign checks and vouchers: in the event of the absence or incapacity of the Treasurer, the President is authorized to cosign checks and vouchers.

The Treasurer, the Secretary and those employees who handle funds shall be bonded at the expense of the Society."

Annual Meeting

The Council decided to schedule two General Sessions at the Annual Meeting, to be held on Wednesday and Thursday mornings.

A request of the Technical Institute Division to bestow the James H. McGraw Award upon the recipient at the Annual Banquet was deferred for further consideration. The Drawing Division has started an Annual Award and several other Divisions are considering similar Awards. It does not seem feasible to present all of the Division Awards at the Annual Banquet, and the Council ques-

tioned the propriety of including one of these Awards on the Banquet program, but denying the same privilege to other Divisions of the Society.

It has been the custom in the past for the host institution to invite the Council members and their wives to a dinner, the cost of the dinner being defrayed by the host institution. It was understood that each host institution should decide for itself whether or not it wanted to provide a dinner for the Council members and their wives, and that the host institution should not be obligated by precedent.

Professional Training Program of ECPD

Mr. McKeon presented a summary of the ECPD proposal for providing the engineering graduate in industry with a continuation program of education and professional development during the first five years after graduation. This program would include: (1) orientation and training of the young engineer, (2) continued education at the graduate level, (3) integration of the young engineer into his community, (4) professional registration, (5) self-appraisal methods for evaluating personal characteristics, and (6) a bibliography of suggested reading material. Upon the recommendation of the Executive Board, the General Council voted to endorse the ECPD project and appropriate $500 for the first year's operations, contingent upon appropriations being made by other engineering societies toward this project.

Location of the 1953 Annual Meeting

Invitations have been received from Oklahoma A. & M. College, the University of Florida, Clemson College, Pennsylvania State College, Iowa State College, the University of Illinois, and Case Institute-Fenn College in Cleveland. President Dawson requested that the Council members express their views on their choice of location for the next Annual Meeting.

Membership Status of Servicemen

The General Council voted to continue the membership of persons in the armed services on an inactive membership status. Their dues would be waived during the period of active military service, and their names would be removed from the Society mailing list. However, such persons would be permitted to resume their active membership in the Society upon completion of the military service without interruption in their membership record.

Manpower Survey

The Manpower Committee of the ECAC has proposed to conduct a survey to determine the availability of recent graduates in terms of their distribution in essential and non-essential ocupations, as related to the rearmament program. The General Council had previously appropriated $1,000 for a slightly different manpower survey, contingent upon an equal appropriation by E.J.C., the ASEE appropriation being used subsequent to that of E.J.C. It was decided to allow the ECAC to proceed with the new manpower survey and use the appropriation on the terms originally granted by the Council.

Southeast Section Resolution

The discussion of the Fontana Resolution of the Southeast Section is summarized in the minutes of the Executive Board meeting.

National Science Foundation

The National Science Foundation Bill has been enacted into law. The Presidential appointees for the Science Foundation Board contain three members of the ASEE. These are: (a) A. A. Potter, (b) D. H. McLaughlin, and (c) E. L. Moreland. The Council voted that: (1) the names of the ASEE representatives be transmitted to the individual Council members, (2) that each Council member be personally responsible for transmitting this information to the dean of his college, and (3) that the deans be urged to write letters to their Senators requesting confirmation of these appointees.

Teaching Aids Subcommittee

Vice-President Grinter stated that the Teaching Aids Subcommittee of the Division of Educational Methods had requested full Committee status in the Society in order to provide closer Society supervision over the funds collected and expended by the Committee and also to focus attention of the Society membership upon the work of the Committee. The Committee plans to review and catalog acceptable teaching aids for engineering instruction. A motion was approved that the Subcommittee be given full Committee status and that this Committee should report to the Vice-President in Charge of Divisions and Committees. This will be a temporary Committee which will be discharged upon completion of the project. The Council recommended that the Division of Educational Methods continue its Subcommittee on Teaching Aids in order to carry on the work after the newly formed Committee has been discharged.

ROTC Units in Technical Institutes

A resolution of the Technical Institute Division for the establishment of ROTC units in Technical Institutes was discussed. It was pointed out that the establishment of ROTC units in colleges of the country had been conducted on the basis of individual application by the college to the Army and Navy, and that the same procedure could be followed by Technical Institutes.

Unity of the Profession

Dean Saville reported briefly on the development of the intra-engineering society conference on Unity of the Profession. These developments are summarized in the minutes of the June meeting of the General Council.

UNESCO Representation

It was voted to investigate the possibility of ASEE becoming a permanent participant in UNESCO.

Life Memberships

The General Council voted that life membership should be conferred upon the following applicants: E. L. Clarke, F. Ellis Johnson, J. C. Gray, C. B. Stanton, A. F. Greaves-Walker, C. T. Bishop, H. L. Seward, Guy H. Hunt, and W. C. Krathwohl.

Respectfully submitted,

A. B. BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf Northwestern University
Kansas-Nebraska	Kansas State College	Oct. 13–14, 1950	Kenneth Rose, University of Kansas
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	C. H. Willis, Princeton University
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	Naval Ordnance Laboratory	Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University		E. D. Howe, University of California
Rocky Mountain			J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

For a Real Vacation—MICHIGAN

Annual Meeting of the ASEE, Michigan State College, June 25-29, 1951

By ROBERT J. FURLONG

Administrative Secretary, Michigan Tourist Council

Michigan is called a "Water Wonderland." Implied in this title is the longest shoreline in the nation—3000 miles of it along the Great Lakes. Within Michigan's boundaries are 36,000 miles of rivers and streams. Many of these waters are well known to trout fishermen the world over—the Boardman, the Pere Marquette, the Ontonagon, the Au Sable and the Manistee, to name a few. There are 11,000 inland lakes in Michigan, most of them well stocked with the kind of fish you can catch from a boat or a dock.

Thousands upon thousands of acres of forests form the background for Michigan's mighty water resources. They provide beautiful scenery and offer cover and food for deer, bear, small game and upland birds.

There is a network of good highways throughout the state and bus, train and plane facilities are among the most modern in the Midwest. Accommodations for the tourist range from swank resort hotels to backwoods cabins.

A card or a letter to the Michigan Tourist Council, 114 South Walnut, Lansing, will bring detailed information on where to go and what to see in Michigan.

In the Upper Peninsula, the accent is on the primitive, yet every degree of vacation comfort can be found here. Some of Michigan's most completely equipped resorts and summer hotels are in the Upper Peninsula. Her golf courses are sporty and beautiful. Her paved highways wind through heavy timber and her cities and towns are famous for their hospitality.

The Upper Peninsula's rugged scenery will be long remembered by the vacationist. Her Lake Superior shores with their pictured rocks are famous. Her inland lakes, many of them in out-of-the-way places, are unsurpassed in natural beauty. Here too, are rippling streams well stocked with trout.

Some of the state's most popular special attractions are in the Upper Peninsula. The great Soo Locks, for instance, bring tourists from all over the world to Sault Ste. Marie, Michigan's oldest city. The Keweenaw Peninsula, jutting into Lake Superior, is rich in beauty and history. Many years ago when copper was king, some of America's most roaring boom towns were located here.

At the eastern gateway to the Upper Peninsula is the village of St. Ignace, burial place of Father Marquette, famous missionary explorer. Four miles east of St. Ignace is Mackinac Island where you find yourself in a pre-revolutionary atmosphere. Old Fort Mackinac, the original Astor Fur House and the Old Mission Church are here now just as they were in the 18th century.

There is no monotony in a trip through Michigan. To get from the Upper to the Lower Peninsula you will enjoy an hour-long boat trip across the blue waters of the Straits of Mackinac. Michigan's Highway Department operates huge ferries to transport passengers and cars from one peninsula to the other.

Additional variety will be found in the Lower Peninsula. As the vacationist leaves the ferry at Mackinaw City, he has

From Michigan Tourist Council

Fighting rainbow trout are taken from waters like this in Michigan. With 36,000 miles of rivers and streams, the state offers some of the best trout fishing in the Nation. More fishing licenses are issued in Michigan than in any other state.

Block House—Mackinac Island

a choice of interesting trips. To the west is a drive down the Lake Michigan side of the state. To the east is an avenue of timber along Lake Huron. A third route would take him through the center of the peninsula.

The trip through the western part of Michigan is a journey through one of the best known vacation lands in America. The Lake Michigan shore has miles upon miles of white, sandy beaches. Here are the famous shifting sand dunes. Here too, are never-to-be-forgotten sunsets. Michigan's cherry country, highlighted each year by the famed Cherry Festival at Traverse City, is in Western Michigan. Petoskey, Charlevoix, Glen Lake, Torch Lake, Interlochen—these are names synonymous with the word "vacation" and they are all found in western Michigan.

South along the Lake Michigan shore are the beaches at Grand Haven. Grand Rapids, the world's furniture center, is a highlight on a trip through the western part of the state. No visit to this section of Michigan would be complete without a stop at Battle Creek, famous for its breakfast foods, or a stay at Holland, home of the Tulip Festival.

If the vacationist chooses the Lake Huron shore as he leaves Mackinaw City, he begins one of Michigan's most beautiful drives. He follows a timber-bordered highway along another of the Great Lakes. Here too are cities and towns famous for their special attractions and hospitality—Rogers City, Alpena, Harrisville, Oscoda, the Tawases, Au Gres, Standish and others. Some of Michigan's best fishing is in this part of the state and as in other sections, accommodations to suit every whim are available.

Bay City and Saginaw are included on the drive down the eastern side of Michigan. These cities, created by Michigan's lumber industry are "musts" on every stop-over list.

Continuing down the Lake Huron side of the state, the vacationist reaches the famous "Thumb" area of Michigan, so called because of its resemblance to a section of the mitten-like topography of the Lower Peninsula. The "Thumb" adds materially to the state's rugged beauty. The shorelines here are sometimes jagged, sometimes smooth, but always awe-inspiring.

Southward along Lake Huron the vacationist sees the huge Blue Water Bridge which links this part of America with Canada. Farther south he arrives at the city that put the world on wheels—Detroit.. Here too is legendary Greenfield Village, the transplanted town of revolutionary days assembled and built by Henry Ford.

The trip from Mackinaw City through the center of Michigan takes the vacationist to such popular places at Cheboygan, Indian River, Gaylord, Grayling, Roscommon, Houghton Lake and Clare. Here he will cross the mighty Au Sable River. Inland lakes with their pike, bass, and pan fish are near the highway. A short trip will take him to the West Branch area known to outdoorsmen the nation over. Mount Pleasant, oil capital of Michigan, is on this central route through the state.

Michigan's capital at Lansing, and East Lansing with Michigan State College, add variety to the trip. Southward is Jackson, the Irish Hills area and the University of Michigan at Ann Arbor. Also, some of the state's best developed public recreational areas are found in the southern counties.

Yes, Michigan is a land of contrasts. To the sportsman, it is a fisherman's paradise and a happy hunting ground. To the lover of scenery, it is an adventure. To the young it is a playground. To the history-minded it is a text book. To every vacationer it is "Michigan, a State of Happiness."

The Michigan Tourist Council maintains information offices at: 114 S. Walnut Street, Lansing, Michigan; 19 Cadillac Square, Detroit, Michigan; 230 N. Michigan Avenue, Chicago, Illinois and 1114 Chester, Cleveland, Ohio. The services of these centers are available free of charge.

Educational Maturity Is the Goal

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee

Engineering curricula grew out of the liberal arts, first as options, then as courses of their own. As engineers increased their writings, technical subject matter was substituted for liberal arts courses until the arts content reached a minimum about 1920. Throughout the development of engineering education there has been a trend toward crowding the program with subject matter until today engineering teachers are considering increasing the time to complete the courses necessary for a bachelor's degree.

The liberal arts educator has sailed through such a sea of material that he knows he cannot devise a program which will introduce the student to all subject matter; he, consequently, fixes a minimum number of credits for graduation. Since the student is not preparing for any particular task, the arts faculties are not concerned about blind spots or neglected areas of knowledge.

Engineers have constructed their programs on the basis of needed knowledge or desirable instruction. As their technology expanded, they introduced more and more subject matter; they squeezed out the general material and are now in the process of trying to get some of it back again. They have tabulated percentages of time devoted to each topic and are now spending good effort on the problem of breaking down the percentages to the minimum necessary to get a speaking knowledge of subject matter in many fields. Sometimes they act as if the student will never undertake to study any more after he leaves college; their procedures are designed to insure that this objective will be achieved.

Why not approach the problems as one of intellectual maturity rather than as one of accumulating credits? Let the student arrange a program which will contribute to this most desirable of educational objectives and as a by-product allow him to accumulate knowledge, information and certain of the engineering techniques. Instead of requiring a certain number of hours credit, require a certain number of years of growth, or maturity. Obviously all students will not mature the same amount in a given time, but neither will they accumulate the same number of credits in a given time. If, after four years of effort, they show no signs of maturity, they will occupy the same position now occupied by their brethren who do not have the hours or the quality credits.

Time Element

If we consider maturity as the objective the time element must of necessity be very important. A child of four is quite different from a child of eight; a youth of eighteen is very different from a young man of twenty-two. During the four year period from eighteen to twenty-two the mental stature is determined. If the prospect does not show promise by twenty-two he will probably never be more than an average intellectual. We can, with considerable assurance, fix the period of desirable educational experience and then fit the program to the greatest possible growth of those who pursue it.

* Presented at a meeting of the Southeastern Section, Fontana Village, N. C., August 28, 1949.

If the instrument should register a quantity at all it would be negative, showing injury to the student rather than help to his thought process. Overstreet, in "The Mature Mind," suggests: "Mediocrity is marvellously transmissible by contagion, and never more than in the area of speech." Contact and contagion loom high in the educational process, and they apply to much more than speech.

Teach them how to write and to express themselves, is the second great objective of the "old grad." In this admonition he is seeking the same objective expressed in different language. If they can't think, they can't write; they have nothing to write about. "I know what I mean but I can't express it" is a confession of lack of thoughts. Thoughts are done in words, ideas pass through the mind by the use of words. If the student does not have the word equipment he cannot do thinking or harbor ideas. First teach them how to read, then point out some of the devices used to get good expression and, after that, they may have some of the equipment for thinking. Repeating by rote is not thinking, but the memory has much to do with the thinking processes of all who think. "Imagination is: mental synthesis of new ideas from elements experienced separately."

Now what is all the shouting about? We have criticized subject matter curricula, what better have we to offer? First we should determine that the student will be subject to four, five or seven years of educational experience and then decide on the program which will best develop him as a mature student. To begin with, we must assume that there are certain subjects which must be omitted because of lack of time; we must further decide that we cannot discuss all the possible topics in many of the subjects we will teach. We must devote much time to eliminating subject matter which does not contribute to the development objective. Educational growth is our major objective rather than the acquisition of information, though we must remember that the two go hand in hand, the information being a by-product of the growth.

It is very desirable to have plenty of subject matter in excellent form in order that the teaching may be devoted to the education of the engineer and not in finding desirable materials for classroom activity. The student will develop more rapidly in a good pasture than in a barren and dry subject. There is no relation between goodness and difficulty of acquisition. As a matter of fact, the difficult material is much more apt to be useless than the easy materials. Much of the argument for discipline is pure bunk.

Cultivate Interest and Zeal for Knowledge

We learn much more rapidly if we are interested, too much energy is lost in dry deserts trying to get interest where none can exist. Emerson, in his essay on "The American Scholar," has used the phrase: ". . . and by concentrated fires set the hearts of youth on flame."

We will try to illustrate what we mean by a brief discussion of sequence courses; courses which develop new principles but require knowledge of all the sequence to perform with requisite skill. Physics, mechanics and elementary structures offer an excellent example; physics, electric circuits and electric design comprise another; chemistry, unit operations and chemical engineering design afford another; and, finally, physics, thermodynamics and refrigeration supply another.

In these sequence courses the student begins with elementary laws and with each new course he adds to his stock in store until he is able to solve complex problems or to discuss complex situations. He cannot discard the elements as soon as they are learned; his subsequent study emphasizes the necessity for fundamentals; each new step pre-supposes a knowledge of what has gone before. When he reaches the end of the sequence, provided he has assimilated the principles step by step, he will have marched in the direction of maturity.

There are many pitfalls along the way. Students prefer to deal with things rather than ideas; they prefer to manipulate numbers rather than to deal with principles. The teacher must be alert to his objective or he will loiter in the brier-patch of details and routines. Laboratories are excellent teaching aids when correctly used, but they can descend into details of reading gauges and reporting columns of figures, if the instructor "don't watch out." When a laboratory report requires hundreds of similar computations it becomes a chore rather than an aid to education. Undergraduate laboratory courses are usually designed to get manipulative skill and to confirm some law which is already known; both objectives are good provided they contribute to the general growth of the student.

Routine exercises, required by an uninteresting instructor, kill the soul of education and leave only the shell of conventional performance. It is possible that the stiff rigid curriculum of the engineer has a tendency to make him stiff and rigid. Everything is prescribed. The trend is toward the same required courses for all who graduate. It may be that we get some semblance of needed coverage, but we may be deflecting the student from the real objectives of education: namely, th ability to study in a field and to determine what is true and what is false.

We should discover those who have motivation, those who have a will to do and then clear the tracks for their development. If we straight-jacket them we may destroy the desire for education.

A sequence of topics offers a chance for the student to grow in stature and mental ability. If he keeps the fundamental laws ever before him and realizes that the complexity of the problem is unraveled by the application of very simple principles he will not be lost in the minutia of manipulation. Study of this type may not cover as wide a range of subject matter as our present plan but it may lead to understanding of elementary laws in such a way that they may be applied to simple problems. The proverb puts it: "Wisdom is the principal thing; therefore get wisdom; and with all thy getting get understanding." An ounce of understanding is worth a ton of memory without understanding. Take a few topics and understand them rather than many topics to skim through them without understanding.

But some one will say: "All students do not have the same capacity for growth and development." This is very true, but the remedy is not to give them applications which the least able can do. By emphasizing manipulations the teacher is apt to stunt the good students and polish the poor ones.

No teaching method has yet been developed which will be equally good for the wise and the foolish. Probably the procedure to take, in the method I propose, is to let the good ones keep going and let the laggards go as far as they can. This will only mean a measure of minimum development for recommendation for graduation. Measuring may be a little more difficult than our present scheme but a measure can be found. Under the plan we can substitute time and more effort, for ability to quickly comprehend. As yet we have not been able to strike an optimum balance between alacrity and "slow but sure." We can devise problems or questions which will measure the thing we are seeking, and after some experience, we will be able to determine the place on the scale which will warrant graduation.

Reorientation of Objectives

We have discussed some of the possibilities of considering education as intellectual growth rather than as a series of courses; we have suggested sequence courses as being the key to the learning process. No program can be designed to give all the knowledge and all the information that the practitioner needs; he must continue to be a student as long as he is a practitioner. He must, therefore,

spend the time allotted to formal study, in such a way that he will get the greatest long time dividends. This will mean emphasis on principles, the understanding of principles with only enough applications to get better understanding and the method, approach and spirit of engineering. We will still give organized courses, as we do under the present plan, but their objectives will be more clearly stated. We will not be lamenting that we do not have time for this and that course; we will decide that any well designed and enthusiastically given course will contribute to the chosen objective.

Engineers will take their training in science and technology, lawyers will take their training in the law, doctors will take their training in medicine and the preachers will take their training in theology, but basically, they will all be doing the same thing, namely, exposing themselves to intellectual growth, and academic maturity. They will not all arrive at the same point of excellence; some will remain juvenile as they do under the present plan. Those who mature will be grounded in the principles which they have studied and they will have enough maturity to continue their studies under their own initiative. Whenever they need more information or more knowledge of a new subject, they will continue their studies until the requisite information or knowledge has been acquired.

As the "old grads" come back and tell me they wish they had had a course in psychology, public speaking or complex variables, I realize that our present emphasis is in the wrong place. The graduate goes out expecting to use his four years preparation in solving all the problems of practice instead of using it as preparation for the solution of any kind of problem that may come his way. If the college work has been done according to the growth plan the graduate will have enough intellectual maturity to get the needed knowledge to solve the many problems which may come into his practice. He may never encounter the heat balance or the chemical balance that he had in college but he may have hundreds of problems which may be solved after the same manner.

The course conscious student *needs a course in it* before he can attack problems in a new field. His education has been neglected. He has failed to get the right point of view while he was trudging through college. His account with the Registrar was not broad enough to cover all his possible needs. Many practicing engineers are using materials which were not discussed in college, they are using methods which were not common, and no doubt many of them are using knowledge that their professors never had. Intellectual maturity is all that is needed to meet any reasonable problem of ordinary practice. If the problem is special, call a specialist, and if a specialist is not available become one yourself.

Going to college is not the process of learning where one can get information if needed; it is not learning a list of things which may be useful in after life; it is a growing time, it is a time when students put away childish thinking and become mature, it is a time when the learner develops self confidence which will allow him to enter his work with a full knowledge that he is a man. If he does not know, he knows how to find out; if he does know, he knows that he knows; he no longer leans upon the professor as a crutch but respects him if he was a good teacher and forgets him if he had memorized his stock in store. Let us design our programs to develop maturity rather than to acquire knowledge and information.

Tests and Testing Programs of Interest to Engineering Educators

By A. PEMBERTON JOHNSON

Educational Testing Service, Princeton, N. J.

I would like to consider with you a brief history of the Measurement and Guidance Project, the need for finding prospective engineers early in high school, tests for student selection at various educational levels, effective use of test scores, and a look to the future.

The Measurement and Guidance Project

Since the end of World War I, the ASEE (then, of course the SPEE) has been interested in the use of tests in student selection and guidance. Dean Hammond, the late Dean Sackett, President Cullimore and many others have devoted many years of work to this area. In 1941 the SPEE and the Engineers' Council for Professional Development began a joint project which, in 1943, became the Measurement and Guidance Project in Engineering Education. It was sponsored until 1948 by the ECPD, the ASEE, and chiefly the Carnegie Foundation for the Advancement of Teaching. One estimate has placed the amount of Carnegie support during the Project's biggest year at $30,000 to $35,000. In 1948 when the Educational Testing Service was formed by merger of the non-profit testing activities of the College Entrance Examination Board, the Cooperative Test Service of the American Council on Education and the Graduate Record Office of the Carnegie Foundation, the Project was made a responsibility of the Educational Testing Service. At that time all ASEE, ECPD, and Carnegie Foundation financial support was withdrawn. In the two and one-half years of ETS operation the project has accumulated a comparable deficit of approximately $44,000, nearly all of which resulted from the expensive nation-wide administrations of the Pre-Engineering Inventory, the last of which took place on June 25, 1949. Beginning in December 1949 a new test, called the Pre-Engineering Science Comprehension Test, was added to the world-wide administrations of the College Entrance Examination Board. During this past year the Pre-Engineering Inventory has been administered locally in about 25 institutions to about 5000 applicants and enrollees. The Sophomore Engineering Achievement Examinations (the other battery of the Measurement and Guidance Project) were used by 9 institutions for about 2000 students.

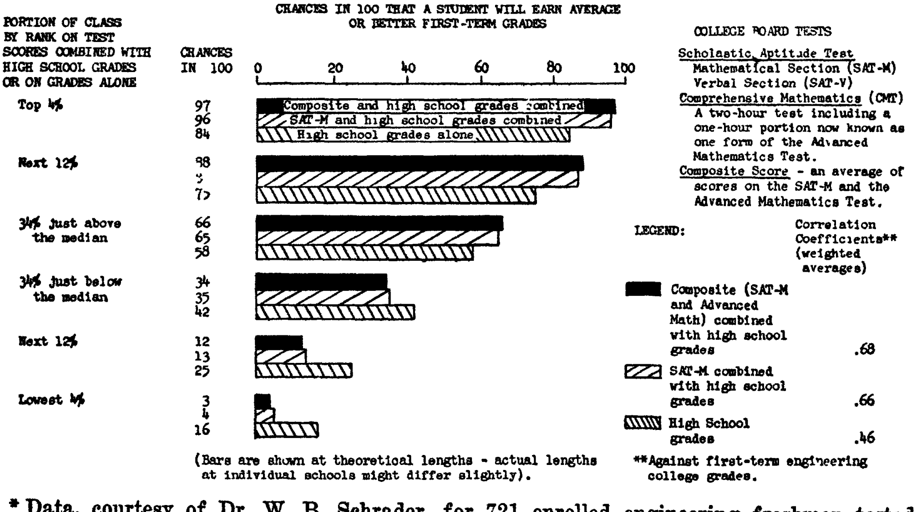
Finding Prospective Engineers

The May 1950 issue of *Mechanical Engineering* reviews briefly a report of a subcommittee of the Committee on Manpower of the ASEE in which it suggests that unless a greater proportion of high school graduates goes into our engineering colleges a shortage of engineering graduates will occur during the period 1953 to 1956. The accompanying chart entitled, Reported Past and Predicted Future Freshmen Engineering Enrollments From 1925 to 1961 in the United States, will give evidence of that.

Some engineering colleges, particularly, I understand, in the mid-west and here in the far west, are expecting a marked reduction in the number of en-

tering freshmen students in September, 1950. One institution in the Pittsburgh area has inquired about testing prospective applicants in the first semester of their last year in high school rather than midway along in the second semester. Mr. Z. G. Deutsch, Chairman of the ECPD Committee on Student Selection and Guidance, and his group who are preparing a new engineering guidance pamphlet to replace "Engineering As A Career" are setting up their pamphlet to appeal to 9th and 10th grade students, i.e., students in the first two years of high school. Educational Testing Service is seriously considering instituting active planning discussions with engineering college, local, industrial, and high school officials in a nearby community to explore the advisability of developing a differential level battery of tests for use chiefly in the 9th and 10th grades. Your comments on the desirability of this would be appreciated. It is intended that this battery would enable at least a preliminary determination of potentiality for engineering college as compared to technical institute training or apprentice or mechanic's training. At the 9th grade level the Cooperative Mathematics Test for grades 7, 8, and 9 is available as a means of evaluating competency in mathematics which, according to the majority of studies, is the single area in which a test score gives the best prediction of later engineering success. This test requires 80 minutes. The Cooperative Algebra Test (Elementary Algebra through Quadratics), requiring 40 minutes, is suitable for students who have completed elementary algebra and may be preferred because it is shorter. Similar 40 minute tests are available in plane geometry, solid geometry, and trigonometry.

EXCELLENT PREDICTION OF SCHOLASTIC SUCCESS
IN
A GROUP OF FIVE ENGINEERING COLLEGES
BY
COLLEGE BOARD TEST SCORES COMBINED WITH HIGH SCHOOL GRADES *



* Data, courtesy of Dr. W. B. Schrader, for 721 enrolled engineering freshmen tested during their first week in the Fall of 1948 at Carnegie Institute of Technology, Cornell University, Lehigh University, Rutgers University, and the University of Pennsylvania.

Educational Testing Service, P. O. Box 592, Princeton, N. J., May 8, 1950.

REPORTED PAST AND PREDICTED FUTURE
FRESHMAN ENGINEERING ENROLLMENTS FROM 1925 TO 1961
IN THE UNITED STATES

Predicted enrollments assume that the proportion of high school graduates enrolling in engineering colleges will remain at 3%—the 6-year average for 1936 through 1941, and the proportion which existed in 1949.

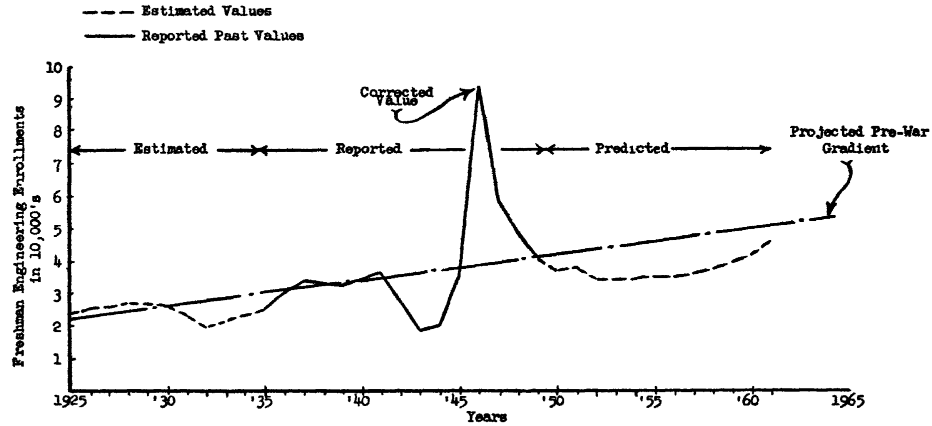


Chart compiled by A. Pemberton Johnson, Educational Testing Service, Princeton, New Jersey, June 12, 1950.

Sources of Data: *Up through 1948*—Hollister, S. C., "Post-War Engineering Enrollment Rapidly Adjusting to Near Pre-War Level." J. of Engrg. Educ., Vol. 39, No. 7, March 1949. *1949–1961*—Based on data from U. S. Office of Education, some by courtesy of Dr. H. H. Armsby, 1/23/50.

At the 9th grade level an 80-minute Cooperative Science Test for grades 7, 8, and 9 is available as a measure of basic competency in Science. The following 40-minute tests may also be useful: Cooperative General Science Test (high school); Cooperative Chemistry Test (high school); and Cooperative Physics Test (high school). At the 10th grade level the American Council on Education Psychological Examination for High School Students and the Cooperative General Achievement Tests seem particularly promising. High school administrators, teachers, and guidance officers can be encouraged to "spot" students scoring high on mathematics and science tests and performing well in classes in these subjects so that representatives of engineering colleges can talk with these students about the advantages of an engineering program of study. Such students should be invited to engineering college Open House Days, Career Days, and the like.

Selecting Prospective Engineering Students

a. Selection of students at a distance—The College Entrance Examination Board Scholastic Aptitude Test only, or the Scholastic Aptitude Test plus the Intermediate or Advanced Mathematics, Spatial Relations, and Pre-Engineering Science Comprehension Tests make an excellent selection device at a distance. Or as a substitute for one of the foregoing achievement tests the English Composition, Chemistry, or Physics tests, whichever of the latter two a student may feel best prepared in might be used. One institution requires the Social Studies plus two other achievement tests. The accompanying chart shows the improve-

ment in the effectiveness of prediction obtained by adding test scores to high school grades. (Explain) In each of these five schools the test score gives a higher prediction alone than do high school grades. However in one institution with a high selection on the SAT-M, the SAT-V is more predictive than the SAT-M Score.

b. Selection at the campus—The Pre-Engineering Inventory, Short Form, which includes the four tests of General Verbal Ability, Technical Verbal Ability, Comprehension of Scientific Material, and General Mathematical Ability, or the Long Form, which adds to the four previously named tests Ability to Comprehend Mechanical Principles, Spatial Visualizing Ability, and Understanding of Modern Society, provides alone or in conjunction with previous high school grades an excellent prediction of scholastic success in the first year in colleges of engineering. The median correlation with first-term grade averages at 12 schools is .60. Because the Pre-Engineering Inventory is available to any school as an admissions or guidance instrument, it is suggested that each institution ask each examinee whether he has taken the test previously and if so, when and at what institution. If the applicant is honest in replying, the college will be informed of previous experience on the test which may have the effect of raising his composite score several points. (This might well be done for any test, of course.) The Pre-Engineering Inventory is available to any engineering school at prices varying from $1 to $3.40 per examinee depending upon whether the institution does its own scoring or obtains scoring, reporting, and statistical tabulating service from Educational Testing Service. By action of the Advisory Council this winter the Pre-Engineering Inventory has been made available to technical institutes and to junior colleges under the rental plans varying in cost from $2 to $3.40 per examinee and providing in both plans that scoring and reporting is done by the Educational Testing Service.

There are, of course, a number of other tests used by individual institutions. The other tests most frequently mentioned are the American Council on Education Psychological Examination and the Cooperative English Test along with local math tests.. The Kuder Vocational Preference Record and the Strong Vocational Interest Blank were also frequently mentioned.

Placement and Guidance

A number of institutions including, of course, most of the state universities are not in a position to be able to require tests of applicants prior to admission but find tests of great value for guidance purposes and for placing students in different sections in mathematics, in English, and in other subjects. Tests used for placement purposes must be available at the beginning of the fall semester and must be adapted for quick scoring locally. The Pre-Engineering Inventory under the institutional scoring plan meets these requirements except for placement in English. It is longer and has more parts than are necessary for the prediction of scholastic success. These parts, however, are useful for guidance purposes. Institutions which wish to use only one or two tests for purposes of predicting scholastic success with the test given to enrollees at entrance can use one or two measures which cost less than the Pre-Engineering Inventory. Among the tests which have proved to be effective in several institutions as predictors of scholastic success are the Cooperative Intermediate Algebra Test; the Cooperative General Achievement Test, Part III, A Survey Test in Mathematics, Form P; and the USAFI Test of General Educational Development, College Level, Test III, Interpretation of Reading Materials in the Natural Sciences, Form B. The Cooperative Intermediate Algebra Test together with rank in high school class has shown excellent prediction at Cornell and Purdue Universities comparable to

the predictive effectiveness of the College Board composite combined with high school grades as shown in black on the bar chart.

Dr. Ralph Berdie at the University of Minnesota has recently reported, in the February Journal of Educational Psychology, the usefulness of one of the Cooperative General Achievement Survey Tests in Mathematics and the USAFI General Educational Development Test in Natural Sciences named above together with percentile rank in high school class. They have been found to be the most effective combination for predicting success in the Institute of Technology. An unusually high predictive effectiveness is reported for the majors in chemistry and chemical engineering, all of whom had chemistry in high school. For other groups in the Institute these measures together with the revised Minnesota Paper Form Board (a spatial relations test) have a predictive effectiveness comparable to that of the Scholastic Aptitude Test of the College Board combined with high school grades.

There are some tests coming into use for which we have no validity data yet. Among these is the Cooperative Mathematics Pretest for College Students, prepared by the Committee on Tests of the Mathematical Association of America, and which is now used by a number of institutions. Its primary purpose is for placement in appropriate college mathematics courses.

A new series of equivalent tests in Spanish and in English known as the Cooperative *Inter-American* Tests in General Ability, Reading, Social Studies, Natural Sciences and Language Usage are particularly useful in those portions of this hemisphere in which it is desired to compare Spanish language students with English language students on the same test content.

The Unit Tests in Engineering Drawing are useful in the evaluation of students who seek credit for previous drawing experience. Professor Paffenbarger of Ohio State was chairman of the committee which developed these.

It is at the end of the freshman year that Professor Slaymaker at Case Institute of Technology chooses from among his enrollees students to enter their engineering administration curriculum. It is my understanding that he has found it inadvisable to admit to that program any students who do not score rather high on the Understanding of Modern Society part of the Pre-Engineering Inventory.

Prediction of Scholastic Success in the the Last Two Years, Including Evaluation of Applicants for Transfer

At least three devices are in use as means of evaluating students at the end of the sophomore year as a basis for predicting their scholastic success in the last two years. These devices are:

(1). Scholastic index at the end of two years. Several institutions have set minimum cumulative grade-point averages at the end of the sophomore year, falling below which disqualifies a student for continuance in the institution. Purdue University uses the same average to disqualify a student at the end of the freshman year as at the end of the sophomore year. Princeton University sets an increasing minimum average grade which a student must meet to go on to the next year's work. It is my understanding that other schools have adopted variants of the same general plan.

(2). Comprehensive Sophomore examinations. The Sophomore Engineering Achievement Test are an example of this device, as are certain of the Cooperative tests and the U. S. Armed Forces Institute tests in Engineering College subjects.

(3). Transfer tests. A new program of Intermediate Tests for College Students was introduced this year as a means of evaluating the qualifications for transfer of students who had one or more years of college training. As administered on May 13, 1950, the Intermediate Tests included a College Ability Test and Pro-

ficiency Tests in five areas: Humanities, Life Sciences, Mathematics, Physical Sciences, Social Sciences. Each applicant took the two parts of the College Ability Test: the Verbal Comprehension and English Expression section, and the Quantitative Reasoning section, as well as two of the afternoon Proficiency Tests. At least one institution with an appreciable number of transfer applicants in engineering, the Newark College of Engineering, has used these tests this year. Dean Hazell and Professor Entwisle there, in addition to requiring the test of transfer applicants, have administered the College Ability Test to all of their own sophomores and have chosen from among both groups on the basis of test scores and previous college records. Although it will be more than a year before we can prove the effectiveness of this approach, we are confident from experience at the entrance to law school level that this approach offers unusual promise for effective prediction of later scholastic success.

Selection at the Graduate Level

With the growing emphasis on graduate level training in engineering many institutions may wish to know of the Graduate Record Examinations which are given in two programs: Institutional and Independent. The Institutional Program involves testing all of a given class or group at a given institution. The Independent Student Testing Program provides for individual registration and testing of single students at centers throughout the country. Scores from either program can be reported to any institution. The Independent Program provides for the reporting of three scores without any transcript cost whereas a $1 transcript fee charge is made for sending to one institution scores of students tested elsewhere. Unless an institution wishes to obtain indications of a student's knowledge in areas other than engineering, it is normally recommended that he take the 3-hour aptitude test and the 1¾-hour advance test in engineering. It is esti-

E.T.S. Tests and Testing Programs of Interest to Engineering Educators

College Senior—Graduate School Level
- Graduate Record Examination (GRE)
  - Nationwide Independent Student Testing Program
  - Institutional Testing Program
  - (Both GRE programs include a new Aptitude Test; Profile Tests; and Advanced Tests in Chemistry, Engineering, Mathematics, Physics and 14 other subject areas)

College Sophomore Level
- College Transfer Test (Intermediate Tests for College Students)
- Sophomore Engineering Achievement Tests
- U. S. Armed Forces Institute College Level Tests in Engineering (various subjects)

College Entrance—College Freshman Level
- College Entrance Examination Board Tests
- Pre-Engineering Inventory
- A.C.E. Psychological Examination for College Freshmen
- Cooperative English Test. Single Booklet Edition (Higher Level)
- Cooperative General Achievement Tests in Social Studies, Natural Sciences and Mathematics. (Proficiency and Survey forms)
- Cooperative Mathematics Pre-Test for College Students
- Cooperative Intermediate Algebra Test
- Cooperative General Education Development Tests (College Level) in areas of English Expression, Literary Materials, Social Studies, and Natural Sciences.
- Cooperative *Inter-American* Tests of General Ability, Reading, Social Studies, Natural Sciences, and Language Usage (Parallel editions available in Spanish and English)
- Unit Tests in Engineering Drawing

Secondary School Level
- ACE Psychological Examination for High School Students
- Cooperative General Achievement Tests (Proficiency and Survey forms) for 10th to 13th grade
- Cooperative *Inter-American* Tests

mated that about 800 students have taken these tests this year. At two different institutions, U. of Michigan and the U. S. Naval Postgraduate School, validities of .42 and .52 have been found. You will be interested to know that the advanced test in engineering has been criticized by some as not giving evidence of research or creative ability in engineering and that plans are now being formulated for the revision of this test with the help of an advisory committee to provide a better measure of these qualities. If an institution desires to have indications of a student's knowledge in areas other than engineering, such as history, social studies, fine arts, etc., the graduate applicant may be asked to take the Profile Tests of the Graduate Record Examination series. A high level average score on these tests is evidence of breadth of background on the part of the applicant.

Perhaps some of your students and about a thousand candidates in all (if I recall correctly) took the Atomic Energy Commission Fellowship Record Examinations this year which were developed and administered by Educational Testing Service.

Effective Use of Test Scores

I believe that we need the ablest staff members we can get to make proper use of test scores. Ideally they would be: (1) deeply interested in students as individuals, (2) well informed about their college and the engineering profession generally, (3) well informed about psychological tests and sound counseling techniques. They should have developed a close coordination with a psychological clinic to which the more difficult counseling cases could be referred.

An essential instrument is a Freshman Counseling Record. The form used by Purdue University contains, on the front, the integration of data from the Admissions office, the Testing office, and the Registrar's office. On the back is a place for a counselor in the Dean's office to record a "patterned" interview seeking to get at each student's motivation, his personality, his knowledge of engineering work, and his enthusiasm for his present studies. Newark College of Engineering gives applicants a little booklet explaining why they are asked to take the pre-engineering inventory tests.

A Look to the Future

May I propose the following for your consideration?

a. The development and encouragement of the ablest possible counselors at each institution, particularly in carrying out local validity studies.

b. The compilation and early wide dissemination of down-to-earth descriptions of effective counseling programs and of the results of validity studies.

c. The active exploration of the motivational, personality, and interest areas by whatever means are feasible.

d. The active development, in conjunction with administrators and guidance personnel in secondary school systems, of adequate programs of informing 9th and 10th grade students regarding engineering values and opportunities and regard ing their own qualifications for the study of engineering.

Water Resources Planning and Development in the Civil Engineering Curriculum

By MILTON O. SCHMIDT

Associate Professor of Civil Engineering, University of Illinois

At the University of Illinois the civil engineering student who elects the Hydraulic Option at the beginning of his senior year is required to enroll in a course entitled "Water Resources Planning and Development." This course which was first offered in September 1942 is probably the only one of its type in a major American university. The content of the course has been made flexible but follows in a general way the topical headings in the accompanying outline, although the latter is considerably more comprehensive than time usually permits.

Water Resources Planning and Development can be considered as the orderly and systematic appraisal of the water resources of a given drainage area, the statement of the problems social and technologic, which are intimately related to water, and the delineation of the methods which can be utilized to effect amelioration of the existing conditions. Water Resources Planning is exceedingly broad in scope and good planning is highly dependent upon the engineers' comprehensive understanding of many diversified aspects such as flood control, navigation, water supply, pollution abatement, wildlife protection, and others. Hence, correct physical data, engineering judgment of the highest quality, and broad experience in the successful solution of similar water problems can be said to constitute the base on which intelligent project planning is founded. Water Resources Development requires, in addition, persuasive protagonists in order to translate the plan into the project.

Formulation of the basic policies of a sound water planning program must be done by those who have had years of experience with similar hydraulic engineering problems and are conversant with the impact of irrational and stop-gap water planning upon the lives and material welfare of many of our citizens. The disastrous floods of the Columbia River, pollution of the upper Ohio River and its tributaries by municipal and industrial wastes, progressive silting of our reservoirs, and problems affecting ground and surface water supply throughout the nation have served to focus attention on the acute need to secure fundamental hydrologic data and to evolve from a consideration of probable benefits and estimated costs an economic analysis of many needed projects.

The general purpose of the course in Water Resources Planning and Development is to broaden the perspective of the student who believes he may enter the practice of some branch of Hydraulic Engineering in order that he may develop an appreciation of the fundamental importance of our water resources, better understand the interrelations of water uses, and be assisted in future problems which may confront him dealing with formation and evaluation of water planning programs.

It is hoped that this course facilitates the acquisition of a limited amount of factual information regarding the major physiographic provinces of the nation, an acquaintanceship with the most acceptable methodologies used in the prep-

aration of drainage basin plans, and that a general understanding of the many different water planning problems in the United States is imparted to the student together with an introduction to the most feasible solutions.

There are no textbooks on this subject. Hence, recourse must be had to any of the numerous federal, state, county, and local water planning studies in order to implement the instruction. The student will find these reports worth studying for other reasons than their technical content for they provide an insight into the manner of presenting the multifarious problems of a single river basin in a report that provides an integrated and co-ordinated picture of conditions as they exist and points the way to possible solution. Careful marshalling of the facts, the use of idiomatic language, and proper attention to the details of good format express in essence the qualities of a superior water planning report.

This semester course requires three one-hour class meetings each week. The pre-requisites are the completion of courses in Hydraulics and Hydrology or concurrent registration in the latter. At Illinois the student in the Hydraulic Option also receives co-ordinate instruction in the senior year in Water Supply and Sewerage, Water Power, and Drainage and Flood Control.

The major part of the section on Inventory of Water Resources is given in a separate course in Hydrology but is included in this outline primarily to indicate the extent of instruction in Hydrology which is considered to provide the desired background for the parent course.

Course Outline

I. Introductory
  - A. National resources
  - B. Planning—the broad viewpoint
  - C. Water resources planning and development—objectives
  - D. Historical—1934 to date

Inventory of Water Resources

II. Hydrologic Principles

III. Precipitation

IV. Ground Water
  - A. Basic concepts, definitions, and terms
  - B. Interrelation of ground and surface water
  - C. Utilization
  - D. Ground water law
  - E. Investigations and surveys

V. Surface Water
  - A. General information
  - B. Regional variations in runoff
  - C. Major drainage basins in the United States
  - D. Drainage basins in Illinois

VI. Stream Gaging

VII. Records of River Discharge
  - A. Availability
  - B. Utility
    1. Design, construction, and operation of hydraulic works
    2. Administration of rights
    3. Litigation
    4. Hydrologic studies
  - C. Length of records

VIII. Quality of Water
  - A. Variation in quality
  - B. Relation to domestic supplies
  - C. Relation to agriculture
  - D. Relation to industry
  - E. Pollution
    1. Domestic sewage
    2. Industrial wastes
    3. Mine drainage
  - F. Silt
    1. Erosion processes
    2. Transportation and deposition
    3. Desilting works
    4. Relation to stream gaging
  - G. Incursion of salt water in tidal streams

IX. Maps in Water Planning
  - A. Types
  - B. Characteristics
  - C. Cartography

Principles and Policies of Water Resources Planning

X. Basic Approach
  - A. The problem—the beneficial control and use of the nation's waters
  - B. Requirements of the problem
  - C. Functions of a planning agency

4. Others
H. Development of recreational areas —part of a multiple-purpose program
I. Drainage of Agricultural Lands
1. Primarily of local importance
2. Horicon Marsh, Wisconsin
J. Erosion
1. Beach stabilization—Lake Michigan
2. Los Angeles County Debris Problems
3. Silting of major reservoirs
4. Coastal erosion
5. Land management and soil erosion

SPECIAL TOPICS

XVIII. Zoning for Flood Control and Water Conservation

XIX. Headwaters Control and Use

College Notes

Establishment of a School of Humanities and Social Studies at the **Massachusetts Institute of Technology** was announced. M.I.T.'s fourth school will have the responsibility for providing the strongest possible program in general education for students studying in the fields of science, engineering, and architecture, and in addition will be a center for creative and professional work in such social sciences as economics, which are appropriate to an institute of technology. Dr. Killian announced the appointment of Professor John E. Burchard as Dean of the new school, which will have equal status with the Schools of Science, Engineering, and Architecture and Planning. Dean Burchard since 1948 has been Dean of the Division of Humanities, which is now replaced by the School of Humanities and Social Studies.

B. Richard Teare, Jr., has been appointed Dean of Graduate Studies in the **Carnegie Institute of Technology** College of Engineering and Science. Dr. Teare is also Head of Carnegie's Electrical Engineering Department and Buhl Professor of Electrical Engineering. He will retain these posts.

A gift of $5,250,000 from the Alfred P. Sloan Foundation, Inc., for the establishment of a School of Industrial Management at the **Massachusetts Institute of Technology** was announced by Dr. Karl T. Compton, Chairman of the Corporation of the Institute. The concept of the school, he said, will be to correlate the complex problems of management in modern technical industry with science, engineering, and research. The objective will be to prepare young men of today better to meet the exacting demands of industrial management as they become the industrial executives of tomorrow.

Loren R. Heiple became Head of the Department of Civil Engineering at the **University of Arkansas** succeeding Professor W. R. Spencer. Heiple formerly taught sanitary engineering at Iowa State College, and was more recently a consulting engineer with Public Administration Service of Chicago. G. S. Hewitt, formerly a director of research with Radio Corporation of America, has joined the Department of Electrical Engineering faculty at the University of Arkansas. He will teach graduate courses in Communications and carry on a research program in the Engineering Experiment Station.

A Survey of First Positions Accepted by Mechanical Engineering Graduates of New England Colleges*

By WILLIAM T. ALEXANDER

Professor of Industrial Engineering and Dean of Engineering
Northeastern University

While it is generally accepted that the primary purpose of the engineering college is to train men for industry, the industrial distribution of mechanical engineering students upon graduation is not generally well known. Consequently, it would appear to be desirable occasionally to examine the types of jobs accepted by our students upon graduation. From such an examination it may be possible to get clues which may aid us in problems of curriculum scope and content.

In considering the request of your chairman that I discuss this topic with you today, it early became obvious that considerable numbers of the graduates of several representative colleges of engineering must be investigated to obtain significant results, and that the alumni office files of the various colleges must be relied upon for data. In order to improve the usefulness of the study, classes were selected for consideration which were relatively recent and also as free as possible from the influence of both domestic and international crises. Although not entirely satisfactory in this respect, the 12 graduating classes 1936–1942 inclusive and 1946–1950 inclusive were selected for study.

The forms reproduced in Table I and Table II were prepared, tested with the data available in the Northeastern University Alumni Office, and mailed to all undergraduate colleges of engineering in the New England Section of ASEE. Six engineering institutions were able to supply partial or complete information, and the study covers 2020 mechanical engineering graduates distributed as follows:

Dartmouth (Thayer School)	33
Mass. Inst. of Tech.	259
Northeastern Univ.	654
Rensselaer Polytechnic Inst.	400
University of Massachusetts	54
Worcester Polytechnic Inst.	620

In order to concentrate on civilian occupations, graduates going directly into the armed forces and those whose records were incomplete or contradictory were eliminated from the tabulations. Types of industries and functions which individually represented less than 1% of the group in each summary have also been eliminated. This gave a total of 1497 individual cases for the summary of industries in Table I and 1011 cases for the functional classification in Table II.

Since the study was carried out on a percentage basis, individual cases were not excluded if they could be used in any one of the tabulations. Consequently, data concerning a given individual may be included in all tables or only in one, depending upon the completeness of the available information.

It should be noted that graduates from M.I.T. and R.P.I. are listed only in the

* Presented before the Mechanical Engineering Conference of the New England Section ASEE, University of New Hampshire, October 14, 1950.

TABLE I

PER CENT OF MECHANICAL ENGINEERING GRADUATES ENTERING VARIOUS INDUSTRIES

(Summary—6 Colleges)

Year**	Manufacturing					Public Utilities			Bus & Auto Auto Mfg	Total Trans.	Smelt. & Refin Steelmaking Forge-Foundry	Pet. & Chem. Ind	Aircraft Ind.	Federal Govt.	Prof. Eng. Firms	Education	Grad Study	Ind. Insur.	Total M.E. Grads. Represented
	Light Mfg	Textiles	Rubber Plastics Abrasives	Heavy Mfg	Total Mfg.	Power & Light	Gas & Fuel	Tot Pub. Util.											
1949–50	24.0	0.9	2.7	20.7	18.6	2.4	0.9	4.2	4.5	4.8	4.2	3.9	4.5	2.1	6.6	3.3	10.5	3.6	333
1948–49	24.5	2.0	1.8	17.8	46.2	2.9	1.8	5.0	3.5	5.0	4.4	5.8	6.4	2.6	7.6	3.5	8.8	2.0	343
1947–48	34.1	1.2	1.2	13.4	50.0	2.4		6.1	2.4	3.7	3.7	2.4	9.8	2.4	6.1	6.1	4.9	2.4	82
1946–47	39.4	-	3.0	28.8	71.2	-	3.0	4.6	—		1.5	4.6	10.6	—	1.5	3.0	1.5	—	66
1945–46*	17.2	1.9	1.0	22.8	42.8	1.9	—	1.9	8.6	8.6	4.8	5.7	10.5	4.8	4.8	4.8	5.7	1.0	105
1941–42	10.2	—	1.1	27.3	38.6	2.3	-	3.4	1.1	1.1	5.7	3.4	20.5	21.6	1.1	2.3	—	—	88
1940–41	20.2	—	1.1	38.3	59.6	2.3	—	3.4	3.4	3.4	6.7	3.4	5.6	5.6	-	3.4	—	1.1	89
1939–40	32.0	—	1.9	29.1	63.0	1.9	1.0	2.9	1.0	1.0	1.9	2.9	10.7	1.0	1.0	4.9	1.9	3.9	103
1938–39	34.5	2.4	—	28.6	66.7	1.2	-	1.2	1.2	3.6	4.8	1.2	8.3	—	—	1.2	3.6	1.2	84
1937–38	44.0	2.0	4.0	10.0	60.0	2.0	—	4.0	—	2.0	8.0	-	6.0	—	4.0	2.0	8.0	—	50
1936–37	44.8	—	—	37.3	82.2	—	1.5	3.0	—	1.5	1.5	3.0	6.0	—	—	—	3.0	—	67
1935–36	43.7	1.2	3.5	20.7	69.0	1.2	3.5	5.8	2.3	2.3	1.2	2.3	4.6	2.3	1.2	—	—	4.6	87
Totals (%)	27.6	1.1	1.9	23.0	54.0	2.1	1.1	4.0	3.1	3.8	4.1	3.9	7.7	3.3	4.3	3.1	5.5	2.1	1497

* 1943–1945 omitted.

** For men on accelerated programs, use "class" rather than date of graduation, if available. Otherwise please indicate method used.

TABLE II

FUNCTIONAL CLASSIFICATION OF POST-GRADUATION JOBS OF MECHANICAL ENGINEERING STUDENTS

Figures are in Per Cent

(Summary —6 Colleges)

Year	Shop Work & Inspection	Erection & Installation	Design & Drafting	Research & Development	Production Supervision	Cost Cont Meth Time Study Prod Plan & Cont	Sales & Service	Own Business	Training Program	Testing	Estimator	Tool Engineer	Teaching Ed Admin	Plant Eng	Fire Preven Eng Safety Eng	Number of Men Represented
1949–50	1.3	0.67	24.8	12.8	1.0	1.7	7.4	1.3	31.5	2.01		0.7	0.67	0.67	7.4	149
1948–49	1.7	2.3	24.8	11.6	2.9	1.7	8.7	1.7	31.8	1.0		0.6	1.2	1.7	4.0	173
1947–48		1.3	22.6	9.3	5.5	1.3	10.7	4.0	20.0	9.3			6.7		2.7	75
1946–47	1.8		22.8	19.3	3.5	3.5	10.5	1.8	26.3	3.5			3.5	3.5		57
1945–46			28.6	17.9	7.1	8.3	5.95	7.1	7.1	6.0	1.2		4.8	3.6	1.2	84
1941–42	4.1		35.2	16.2	2.7	2.7	6.8		20.3	4.1		5.4	2.7		—	74
1940–41	7.3	1.8	27.3	14.5	3.6	3.6	7.3	1.8	14.5	1.8		5.5	5.5		1.8	55
1939–40	11.8		26.3	5.3	5.3	1.3	1.3	2.6	23.7	4.0		2.6	5.3	5.3	4.0	76
1938–39	11.5	2.6	25.7	10.3	2.6		10.3	5.1	20.5	6.4		2.6	1.3		1.3	78
1937–38	6.4		34.1	2.1	2.1	8.5	17.0	6.4	10.6	4.3		4.3	4.3	—	-	47
1936–37	6.2	3.1	27.7	9.2	6.2	3.1	9.2	3.1	18.5	12.3		1.5	—	—	—	65
1935–36	20.5	—	32.1		2.6	2.6	7.7	3.9	12.8	2.6		1.3		5.1	3.9	78
Totals (%)	5.3	1.0	27.0	11.2	4.0	3.3	8.2	3.0	22.0	4.9		1.7	2.6	1.7	2.9	1011

1948–1949 and 1949–1950 classes, and that the Dartmouth mechanical engineering graduates are all subsequent to 1941.

Results of Survey

Although the basic data were neither as extensive nor as clear cut as might have been desired, it is believed that adequate coverage remains to give some rather definite indications of the true situation. It will be noted from the percentage totals of Table I that 54% of the 1497 graduates entered the field of general manufacturing over the 12 class period and less than 10% selected any other single field. The distinction between "light" and "heavy" manufacturing was somewhat arbitrary and probably relatively inaccurate.

An attempt was made to compare the variations in the portion of graduates entering manufacturing industries with the curve of New England industrial activity for the same period, but no significant relationship was noted.

7.7%, overall, entered the aircraft industry, but the popularity of this field increased to a peak of 20.5% in 1942 and since that time has been in a steady decline. Approximately 4% have entered each of the fields of public utilities, transportation, smelting and refining-forge and foundry-steelmaking, petroleum and chemical industry, professional engineering firms, and the Federal Government, but the number of men involved is too small in each case to clearly indicate any trends.

5.5% of the men went on to graduate study during the period studied, but this is an average figure representing a strongly increasing trend which exceeded 10% in 1950. Although this trend is clearly influenced by the "G.I. Bill," it may be noted that 8% went to graduate school from the class of 1937–1938.

There appears to be a decreasing trend in the percentages entering general manufacturing, but it appears probable that this field will continue to absorb approximately one-half of the mechanical engineering graduates.

Table II shows the functional classification of the work performed by 1011 men immediately after graduation. In this table an attempt was made to combine types of work requiring the same general preparation. 27% of the graduates went into drafting and design, and no major trend is apparent. 22% undertook training programs. Here the yearly averages are spotty, and probably the figures given are conservative. It appears that training courses are increasing in popularity as a general trend.

Research and development accounted for 11.2% of the men considered. This field apparently overlaps that of drafting and design and probably represents more development than research. No clear trend is noted over the last 11 or 12 years.

8.2% went into sales and service. This function is spotty and no trend is apparent.

Shop work and inspection with an overall percentage of 5.3 is quite variable in popularity but is apparently steadily decreasing in importance. In the prewar period tool engineering attracted 1.3–5% of the group, but virtually no one from among those studied has entered this field upon graduation during the last 5 years.

The remainder of the functions listed have accounted for small and variable numbers of graduates, but no definite trends are observed.

To supplement the available information concerning the jobs accepted immediately after graduation, an attempt to study job changes in the few years following commencement is summarized in Table III. For obvious reasons only Northeastern graduates could be studied, and those selected comprised 219 students from the classes of 1936, 1940, 1941 and 1942. A period of 6 years of work was selected as best avoiding the war years and from the records of this group of young engineers, 178 cases were available to study the industries involved at grad-

TABLE III

Per Cent of Mechanical Engineering Graduates in Various Industries

(Summary of Status at Grad. and 6 Years after Grad. N.U. Classes of 1936, 1940, 1941, 1942.)

Year**	Manufacturing				Pub. Util.		Bus & Auto Auto Mfg.	Ship Building	Pet. & Chem. Industry	Aircraft Ind.	Government		Prof. Eng. Firms	Education	Misc.	Non Eng. Position	Ind. Insur.	Number of Men Represented	Total M. E. Graduates
	Light Mfg.	Rubber Plastics Abrasives	Heavy Mfg.	Total Mfg.	Power & Light	Tot. Pub. Util.					State	Federal							
A—First Jobs																			
1942	6	—	13	19	—	—	—	1	1	12	—	11	—	—	1	—	—	45	75
1941	12	1	16	29	—	—	1	5	—	3	—	4	—	1	2	—	1	47	56
1940	16	2	6	24	1	1	1	1	2	2	—	1	1	—	—	1	2	40	40
1936	28	—	7	35	—	3	2	1	—	1	—	1	1	—	2	—	—	46	48
No.	62	3	42	107	1	4	4	8	3	18	—	17	2	1	5	1	3	178	219
%	34.8	1.7	23.6	60	—	2.2	2.2	4.5	1.7	10	—	9.6	1.1	—	2.8	—	1.7	100	
B—Six Years After Graduation																			
1942	22	—	10	33	1	1	2	1	3	2	—	4	2	—	1	3	—	55	75
1941	13	—	6	19	—	—	—	2	2	1	1	7	1	3	1	1	2	41	56
1940	10	—	3	13	2	2	1	1	2	1	—	2	2	—	—	—	1	40	40
1936	6	—	12	18	—	2	2	1	3	5	1	4	2	1	1	1	—	47	48
No.	51	—	31	83	3	5	5	5	10	9	2	17	7	4	3	5	3	183	219
%	27.9	—	1.7	45.4	1.61	2.7	2.7	2.7	5.5	4.9	1.1	9.3	3.8	2.2	1.61	2.7	1.61	100	

* 1943–1945 omitted.

** For men on accelerated programs, use "class" rather than date of graduation, if available. Otherwise, please indicate method used.

TABLE IV

FUNCTIONAL CLASSIFICATION OF POST-GRADUATION JOBS OF MECHANICAL ENGINEERING STUDENTS
(Summary of status at graduation and 6 years after. N.U. Classes of 1936, 1940, 1941, and 1942.)

Year	Shop Work & Inspection	Erection & Installation	Design & Drafting	Research & Development	Production Supervision	Cost Cont. Meth. Time Study Prod. Plan & Cont.	Sales & Service	Own Business	Training Program	Testing	Estimator	Tool Engineer	Gen. Office Work	Teaching, Ed. Admin.	Plant Eng.	Fire Preven. Eng. Safety Eng.	Total Cases Represented
A—First Job																	
1942	3	—	21	6	—	1	1	—	8	3	—	4	—	—	—	—	
1941	3	1	11	7	2	2	3	—	6	1	—	3	2	1	—	1	
1940	7	—	13	—	4	1	—	—	4	1	—	2	—	—	4	2	
1936	16	—	17	—	2	—	1	2	4	1	—	—	2	—	2	—	
Tot.	29	1	62	13	8	4	5	2	22	6	—	9	4	1	6	3	169
%	17.2	—	36.7	7.7	4.7	2.4	3.0	1.2	13	3.6	—	5.3	2.4	—	3.6	1.8	
B—Six Years After Graduation																	
1942	2	1	17	12	3	3	3	4	1	3	—	—	—	—	3	—	
1941	—	—	12	7	2	1	6	2	—	2	1	—	—	3	—	2	
1940	—	—	12	2	1	1	5	—	—	1	1	—	—	—	2	2	
1936	2	—	14	4	4	2	7	—	—	3	—	—	—	2	4	1	
Tot.	4	1	55	25	10	7	21	6	1	9	2	—	—	5	9	5	160
%	2.5	—	34.4	15.6	6.3	4.4	13.1	3.8	—	5.6	1.3	—	—	3.1	5.6	3.1	

TABLE V

LOCATION OF FIRST POSITION ACCEPTED AFTER GRADUATION

State	Worcester		Northeastern		M. I. T.		U. of Mass.		Dartmouth		Total Men	%
	No.	%	No.	%	No.	%	No.	%	No	%		
Massachusetts	219	42.0	289	60.0	23	16.7	23	59.0	4	12.9	558	46.0
Connecticut	89	17.0	43	8.9	15	10.9	1	2.6	5	16.1	153	12.6
New York	67	12.8	35	7.2	33	23.9	6	15.4	9	29.0	150	12.4
New Jersey	28	5.4	26	5.4	5	3.6	2	5.1	1		62	5.1
Pennsylvania	28	5.4	9	1.9	6	4.4			3	9.0	46	3.8
Ohio	13	2.5	8	1.7	11	8.0			1		33	2.7
Vermont	3		20	4.1	1				3	9.7	27	2.2
Virginia	13	2.5	8	1.7	3	2.2					24	2.0
Michigan	13	2.5	1		5	3.6			3		22	1.8
Maryland	9	1.7	8	1.7			1	2.6			18	1.5
Illinois	5	1.0	5	1.0	8	5.8					18	1.5
Wash., D. C.			8	1.7	7	5.0					15	1.2
Rhode Island	6	1.2	4								10	0.8
California	4		2		2	1.5			1		9	0.7
Wisconsin	2		2		5	3.6					9	0.7
New Hampshire	1		5	1.0			1	2.6			7	0.6
Maine			4		1		1	2.6	1		7	0.6
Delaware	3		1		3	2.2					7	0.6
West Virginia	6	1.2			1						7	0.6
Indiana	3				2	1.5	1	2.6			6	0.5
Texas	1		1				3	7.7			5	0.4
New Mexico			2								2	
Kentucky	2										2	-
Louisiana					2	1.5					2	-
Tennessee	2										2	-
Idaho	1										1	—
Mississippi	1										1	-
Alabama	1										1	–
Minnesota	1										1	–
Outside U. S.	2		3		4	2.9					9	0.7
Total	522		484		138		39		31		1214	

nation and 183 cases for the situation 6 years afterward.

It will be seen that employment in manufacturing decreased from 60%, which is somewhat above the 6 college 12 class average of Table I, to 45.4%, still a substantial portion of the group.

Employment in the aircraft industry and in shipbuilding substantially dropped, while there was a considerable increase in those associated with the petroleum and chemical industry.

It must be recognized that the relatively few cases involved make it impossible to generalize with any high degree of accuracy.

Table IV summarizes the functional classification at graduation of 169 cases from the above group and of 160 cases 6 years afterward. It is interesting to observe that the percentage of men in drafting and design remained virtually unchanged at 34% and that the college records revealed an orderly progress from drafting to design in the great majority of cases.

As might have been expected, the proportion in research and development

doubled; and the records seemed to show an increase in the research type of activity. The field of sales and service increased from 3 to 13%, shop work and inspection dropped from 17 to 2.5% and the remainder were in the field of inspection.

A moderate increase, which involves relatively few cases, may be observed in production supervision, industrial engineering, testing, teaching, plant engineering, fire prevention and safety engineering, and own businesses.

It is rather surprising that with this particular group tool engineering disappeared within the first 6 years after graduation. Apparently shop work as well as training courses has served as an effective springboard to professional progress and diversification.

While examining the records of this group, it was possible to find 161 cases with adequate data to record the numbers of positions held within the first 6 years after graduation. These figures do not show service in the armed forces, and a man who returned to the same firm postwar is credited with only one job.

No. of Jobs in 1st 6 Years	No. Men	%
1	45	28
2	56	35
3	43	27
4	12	8
5	2	1.0
6	1	0.6
7	2	1.0
Total	161	

It was interesting to note that there was no definite correlation between the number of jobs held within the first six years and a man's professional progress. Apparently, a large number of jobs held may equally well indicate a lack of desirability or the possession of outstanding initiative and ability.

Over the years a high percentage of Northeastern students have accepted first jobs with Massachusetts organizations as may be noted in Table V. This is probably due to the joint influence of the Cooperative Plan and a high percentage of undergraduates from Greater Boston homes. However, there are definite indications from this relatively small group that the geographical distribution is considerably expanded within 6 years after graduation.

Table V tabulates the geographical distribution of the first jobs held by 1214 graduates of all the colleges represented in this study except Rensselaer. Only four states—Massachusetts, Connecticut, New York and New Jersey—have received over 5% of these graduates and the addition of four more states, Pennsylvania, Ohio, Vermont, and Virginia, will include all states attracting 2% or more of the group.

It should be noted that the figures from M.I.T., which has had a wide geographical distribution of its graduates for many years, represent only the classes of 1948–1949 and 1949–1950. It is also clearly evident from the basic records that in the post war period there has been a considerable expansion in the geographical distribution of post graduation employment for both W.P.I. and Northeastern.

Summary

Nearly one-half of 1214 graduates in mechanical engineering from New England colleges accepted first jobs in Massachusetts, and approximately the same numbers, 12.5%, obtained employment in Connecticut and in New York.

Slightly over 50% from the group studied entered the field of general manufacturing, and no other type of industry attracted over 8% from this total group of 12 graduating classes.

In the various industries 27% were engaged in design and drafting, 22% undertook training programs, 11% were in research and development, and no other type of work individually covered as much as 10% of the group.

Within a small group of approximately 170 men whose status immediately after

graduation could be compared with the situation 6 years later, essentially one half of the group were still in general manufacturing, and less than 10% were in any other single kind of activity. Approximately one-third had remained in design and drafting, those in sales and service had increased from 3 to 13%, and the number in research and development had doubled to 15.6% while the numbers in shop work and in tool engineering had radically dropped.

It is to be noted that the nature of the basic records is such that the mathematical results of this study are not of a high degree of accuracy. However, in view of the numbers involved and of the elimination of many doubtful cases, it is believed that some rather definite trends may be observed.

Sections and Branches

The annual fall meeting of the **New England Section** was held at the University of New Hampshire, Durham, New Hampshire, on October 14, 1950. Officers of the Section were invited to attend the Symposium on "Technology in the Service of Mankind," held the previous afternoon and evening in New Hampshire Hall. The following officers were unanimously elected: W. C. White as Chairman, and E. F. Littleton as Secretary. Mr. H. H. Armsby, Vice President of the ASEE, spoke briefly to the group upon the outlook as seen by the U. S. Office of Education. Conferences were held on Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Engineering Physics, English and Engineering Libraries.

A Course in Physical Chemistry for Mechanical Engineers

By MILTON KERKER

Assistant Professor of Chemistry, Clarkson College of Technology

Mechanical Engineering students at Clarkson College of Technology are required to take a two hour lecture course in Physical Chemistry during the second semester of their junior year. This course was previously offered as a senior elective and has proved successful enough to be incorporated into the general curriculum. It is the purpose of this paper to describe the aims and content of the course.

It may at first seem surprising that the already crowded mechanical engineering curriculum should be further encumbered by a specialized course in chemistry. Every teacher of freshman chemistry is well acquainted with the none-too-rare type of engineering student who cannot understand why he is required to study chemistry. In some instances he may be told that chemistry is "broadening" and, like a daily dose of vitamins, every engineer ought to have some. Although this answer may have some merit, it by no means tells the entire story since chemistry is a most practical tool for many phases of engineering work and an essential prerequisite for much of engineering education.

An important part of the mechanical engineering curriculum is concerned with thermodynamics and its application to steam power plants, internal combustion engines and corrosion. In order to treat these topics adequately, it is necessary to consider the kinetic theory of gases, combustion, chemical equilibrium, petroleum fuels, electrochemistry, etc. These latter subjects are generally incorporated in the engineering courses as the need for them arises. However, there is seldom the time to treat them adequately. Since they provide the physical basis for the phenomenon being studied, the student is building upon a weak foundation. It is almost by rote that he learns that corrosion proceeds more rapidly at certain pH's, that the heat capacities of gases vary with temperature or that a certain fuel-air mixture may yield a given maximum flame temperature. If the physical basis for these facts is not understood, the facts themselves cannot be very meaningful to the student. Under such circumstances, engineering education is in danger of being reduced to the technique of reading charts and solving numerical problems. But in order to face new situations, the engineer must do more. For this, he must have a profound understanding of the phenomenon with which he is dealing.

The Department of Mechanical Engineering at Clarkson College has long recognized the need for developing a firm understanding of chemical principles by their students. When the author was asked to prepare a course which would meet the requirements of the Mechanical Engineering curriculum, it was realized that neither the orthodox physical chemistry course nor a watered down "survey" course would do. The year course in physical chemistry for chemistry and chemical engineering students has now become so bulky that the student is offered only a kaleidoscopic picture of the field. To offer such a potpourri, even after eliminating much material, would be a

burden to the non-specialist student. The need was for an integrated short course which would cover a small number of topics of interest and use to mechanical engineers. Since they had already studied thermodynamics and had considerable training in physics and mathematics, it was possible to present the material on at least as high a level as that for the chemistry majors.

A survey of colleges whose chemical engineering departments were accredited by the American Chemical Society was made in order to determine what was being done along these lines at other schools. Only one school which had recently expanded its curriculum to a five-year program offered a course in physical chemistry to non-specialist engineers. This course was given during the sophomore year and was of the survey type, something we wished to avoid.

There was no textbook which fit the needs of the course. It was felt that a textbook of some sort should be provided even if it did not completely conform to the aims of the course. One of the standard undergraduate texts in physical chemistry was recommended, and selected reading and problems were assigned from time to time. However, the course in no sense "followed the book" and mimeographed notes were passed out to supplement the lectures.

The student reaction to the course was excellent. There was general recognition of the relation of the topics covered to their own specialties. Although they knew that as engineers they would not be called upon to solve problems of a chemical nature, they appreciated the broader understanding of their own field to which the study of chemical principles contributed.

Course Outline

The course outline is presented below:

I. Gases
  A. Kinetic theory
    1. Gas pressure
    2. Avogadro's principle
    3. Boyle's and Charles' laws
    4. Molecular velocity
    5. Viscosity
    6. Dalton's law
  B. Some general principles
    1. Atomic and molecular weights
    2. Moles
    3. Avogadro's number
    4. Determination of molecular weights
  C. Deviations from ideality
  D. Heat capacity
    1. Cp and Cv
    2. Heat capacity of the perfect gas
    3. Variation with temperature
      a. Equipartition theory
      b. Quantum mechanical theory

II. Condensed phases
  A. Kinetic theory of liquids and solids
  B. Phase relations
    1. Vapor pressure
    2. Fusion, sublimation, polymorphism
    3. Critical phenomena
    4. The phase rule
      a. Single component system
      b. Two component condensed system
  C. Surface tension
  D. Kinetics of phase transformation
  E. Solutions
    1. Colligative properties
    2. Binary liquid systems, distillation

III. Corrosion
  A. Electrochemical principles
    1. Ionization
    2. Electrolytic conduction
    3. The electrochemical cell
      a. Chemical cells
      b. Electrode potentials
      c. Concentration cells
  B. General theory of corrosion
    1. Rusting of iron in water
    2. Corrosion by applied Emf
    3. Corrosion without application of external Emf
  C. Protection against corrosion
    1. Paints and enamels
    2. Metallic coats
    3. Inhibitive treatment of water
    4. Chemical treatment

IV. Combustion Phenomena
  A. Thermochemistry
    1. Thermochemical equations
    2. Heat of reaction

3. Hess's Law
4. Kirchoff's Law

B. Reaction kinetics
   1. Factors affecting reaction rates
   2. Kinetics of simple reactions
   3. Reaction mechanisms and stoichiometric equations
   4. Chain reactions
      a. The HBr reaction
      b. Chain branching

C. Chemical Equilibria
   1. Law of mass action and equilibrium constant
   2. Factors affecting equilibrium
   3. Solution of equilibrium problems

D. Auto-ignition and combustion
   1. Thermal mechanism
   2. Free radical mechanism
   3. Upper and lower explosion limits
   4. Combustion of hydrocarbons

E. Flame propagation
   1. Experimental procedures
      a. Photography
      b. Shadow method
      c. Schlieren method
   2. Flame velocity from bunsen burner cone

F. Equilibrium temperature and pressure in an adiabatic combustion chamber

G. Petroleum
   1. Organic compounds found in petroleum
   2. Petroleum fractions
   3. Engine knocking and octane rating
   4. Synthetic gasoline

An Analysis of Petroleum Engineering Curricula, and Recommendations for Elective Sequences*

By HARRY H. POWER

*Chairman of Department of Petroleum Engineering
University of Texas*

In 1943 and 1944, a comparison was made of the specialized curricula in petroleum engineering of the petroleum engineering schools of the United States. In response to a questionnaire, course outlines were submitted by most of the schools, and a compilation was made in report form which revealed that committee action was valuable in reducing the large number of course titles and recombining course contents. As a further result of this survey a paper was written (1) stressing:

(1) The general objectives of the Engineering Council for Professional Development in engineering education.

(2) The importance of fundamental science in the engineering curricula.

(3) The engineering-problem method or "quantitative approach" in the teaching of specialized courses. This constituted an abrupt change from the so-called "descriptive approach."

(4) Suggested structures of the specialized courses to meet the requirements of (3).

(5) The role of supporting courses, especially English and Economics.

A sufficient number of years have passed, especially since the termination of World War II, to take stock once more of trends in petroleum engineering education. Accordingly, the curricula of some twenty-two institutions have been analyzed and several noteworthy developments have been investigated for purposes of comparison and comment.

In the examination of engineering curricula for purposes of accrediting, a recognized definition of engineering is a first requisite for the strict approval of such programs. New fields, such as petroleum engineering, have opened since the turn of the century. Some believe such a field to be characterized as a specialization in the function of engineering, while other fields, such as geological engineering and engineering physics, are associated with the basic sciences. Often, the principal problem confronting an examiner is this: "should this curriculum be considered as engineering leading to an engineering degree?" (2).

Engineering curricula are characterized by courses in mechanics, strength of materials, and properties of materials. Based on such studies will be characteristic courses such as "structures, apparatus or machines, and the principles upon which they are designed, constructed and operated." For example, the curriculum in mining engineering contains courses in mechanics, hydraulics, hydraulic machinery, heat engines and electrical equipment. It will also include mathematics, chemistry, physics and geology. This latter group also characterizes a curriculum in geology. It is inferred that the mining engineer plans to design, construct and operate. The geologist is interested in the formation and nature of the earth's crust, but does not

* Presented before the Mineral Engineering Division at the Annual Meeting of the ASEE, Seattle, Washington, June 19–23, 1950.

plan to design, construct or conduct surface or sub-surface operations. Hence the verb *to engineer* is defined: "to plan and direct the formation or the carrying out of; to guide or manage by ingenuity and tact; to conduct through or over obstacles by contrivance and effort" (2).

By *design* is meant "the process of contriving a scheme, system or concept of a device, together with a forecast of behavior thereof, which if built would be appropriate to the functional, economic and safety requirements." Hollister (2), therefore, concludes that:

> "An engineer is characterized by his ability to apply scientific principles to design or develop structures, machines, apparatus or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects a specific function, economics of operation and safety to life or property."

The content of an engineering curriculum beyond mechanics of materials and properties of materials that will enable one to design will vary with the basic field of engineering. In the field of petroleum engineering such identifying courses must be specified as minimum essentials.

Since no curriculum can foretell all the training necessary for the graduate in his professional life, it is impossible to specify all requirements of training, but it is certain that he should be trained thoroughly in broad fundamentals.

Analysis of Curricular Programs

A detailed examination of the curricula in petroleum engineering offered by twenty-two institutions in the United States shows that:

One institution offers separate four year options in development and production;

Two institutions offer separate four year options in production and refining;

One institution offers separate four year options in production, refining, geology and management;

Two institutions offer separate four year options in production and natural gas;

One institution offers four and five year options in petroleum engineering; a five year option in petroleum engineering and business; a five year option in petroleum engineering and chemical engineering; a five year option in petroleum engineering and geological engineering; and a five year option in petroleum engineering and mechanical engineering.

As a result of detailed analyses, the relative emphasis given the various courses composing the curricula is shown in Tables I, II and III.

Combination five-year programs offer the advantages of two degrees in different fields of engineering. Although the advent of such programs has been recent, industry is said to favor the two-degree plan, especially the one combining petroleum and mechanical engineering. It must be admitted that the producing industry is in a large measure mechanical. Mechanical engineers in the field have become petroleum engineers and petroleum engineers have become mechanical engineers. There is no doubt but what each field has its place in the oil and gas business. It remains to be seen whether an all-embracive five-year program in petroleum engineering is in a position to compete with the combination degree plan. However, the programs proposed may be supplemented by five-year programs leading to degrees combining petroleum engineering with mechanical, geological, and chemical engineering. This arrangement should be of sufficient flexibility to permit a choice to meet the most critical employers of engineers in industry.

Although the author is not committed to optional curricula in petroleum engineering, such options do exist elsewhere and have been analyzed in order to present representative programs. Some in-

TABLE I

ANALYSIS OF PETROLEUM ENGINEERING CURRICULA

	Requirements		
	Genera	Secondary	Occasional
Mathematics	Algebra Trigonometry Analytical Geometry Diff. Calculus Int. Calculus	Diff. Eqns. Adv. Calculus	
Physics (Engineering)	Mechanics Heat Electricity Magnetism Light Sound		
Chemistry	General (incl. Qualitative) Quantitative Organic Physical		
Drawing	Elem. Engineering Descr. Geometry	Adv. Engineering Drawing	
Geological Sciences	General (Physical) Historical Minerology Petrology Structural	Petroleum Field Sedimentology Stratigraphy	
Mechanical Engineering	Thermodynamics (and Lab.)	Dynamics of Machines Machine Design Steam Power Plant Internal Combustion Engines Machine Shop	Air Conditioning Refrigeration Graphic Mechanics Natural Gas System Design Conference
Civil Engineering	Surveying	Reinforced Concrete Graphic Stress Analysis Structural Design	

stitutions may elect to offer optional programs plainly designated as such. Others may prefer to offer a wide choice of electives in order to meet, substantially, the general objectives of the optional programs. The author leans towards this latter procedure. (See Tables IV and V.)

A fifth-year program as a continuation of any one of the above sequences may be selected from upper division and graduate courses to meet the requirements of the Master of Science Degree in Petroleum Engineering.

It has been recognized, not only in petroleum engineering, but in most branches

of engineering, that the four-year curriculum is inadequate. When it is realized that most branches of engineering are represented in the oil-producing industry, one must conclude that a very difficult problem is presented in the design of a four-year curriculum in petroleum engineering that will embrace effectively the necessary science studies as well as the various fields of engineering. Not that the petroleum engineer expects to be proficient in all fields as they are applied in the oil and gas industry, but he is cognizant of the broad scope of his duties, which may be compared with those of the mining engineer. Hence, if a four-year program is insufficient for the all-embracing curriculum, it is possible that auxilliary elective sequences might be considered for full development within

TABLE II

Analysis of Petroleum Engineering Curricula

	Requirements		
	General	Secondary	Occasional
Electrical Engineering	A.C. and D.C. Machinery		
General Engineering	Engineering Mechanics (Statics, kinetics and kinematics) Strength of Materials Hydraulics	Elementary Engineering Problems	Engineering Materials Engineering Construction Wood Patterns
Chemical Engineering	Fuels and Combustion Unit Operations Petroleum Refining	Petroleum Industrial Processes Thermodynamics Oil and Gas Technology	Instrumentation and Plant Control
Petroleum Technology	Development Methods Production Methods Laboratory Natural Gas Engineering (and Lab.) Natural Gasoline Design Valuation Reservoir Mechanics Production Engineering Oil and Gas Transmission	Introductory Problem Courses Petroleum Economics Logging Methods Hydrocarbon Analysis Petroleum Testing Phase Behavior Secondary Recovery Seminar	Introductory Descriptive Courses Oil Field Mapping Drilling Muds Industrial Work Field Trips Field Courses
Mining and Metallurgy	Metallurgy and Metallography of Iron and Steel	Mine Surveying	Mine Operations Ore Dressing and Coal Cleaning Prospecting Explosives and Rock Work Investigations Gases and Ventilation Development Methods

TABLE III

ANALYSIS OF PETROLEUM ENGINEERING CURRICULA

	Requirements		
	General	Secondary	Occasional
English and Speech	English Composition Rhetoric Technical Writing and Public Speaking	Literature Advanced Grammar Electives in English	
Business	Accounting Industrial Organization and Management	Commercial Law Oil and Gas Law Engineering Contracts and Specifications Statistics Corporation Finance	Marketing Salesmanship
Miscellaneous	History Government Naval and Military Science Physical Education Orientation		Foreign Languages Psychology Sociology Library Slide Rule First Aid
Economics	General Economics	Engineering Economics	Petroleum Economics Industrial Organization Money and Banking
Electives	Electives in the various institutions vary in credit from three to nineteen semester hours. At one institution, six of the twelve elective semester hours must be in the humanities. Greater freedom in the selection of electives is permitted at the institutions offering optional programs, both in the usual four-year programs, and in the five-year combination programs.		

this time limitation. The addition of a fifth year's program should not only expand the particular sequence adequately, but might serve to orient the various electives chosen to a well-balanced program covering petroleum engineering as a whole. It is not believed that many recommend the optional division of a specialized field such as petroleum engineering, but if the four-year curriculum must be offered, regardless of its limitations, the five-year program should provide an answer to the just criticism of specialization within a specialization.

Several institutions offer "options" in petroleum engineering, the most common ones being: production, development, natural gas, geology, and refining. One institution has mentioned an option in process engineering. Although an option in reservoir engineering has been mentioned in petroleum engineering groups on numerous occasions, no such option is indicated in the current programs of the various institutions.

Alternative fifth-year programs, as continuations of the above sequences, may be selected to meet the requirements for the Bachelor of Science degrees in Mechanical Engineering, Geological Engineering, and Chemical Engineering.

The various programs suggested above will undoubtedly be criticized from the standpoint of present day trends with

respect to: (1) electives in each program, and (2) the humanities. The answer to this criticism is that freedom of choice of the various programs suggested is thought to be sufficiently great to outweigh the comparatively small number of semester hours devoted to humanities and additional electives. Certainly, professional

TABLE IV

FOUR-YEAR CURRICULA IN PETROLEUM ENGINEERING

	Production	Development	Reservoir Engineering	Natural Gas Engineering	Geology	Process
	(Semester Hours)					
Mathematics						
Algebra	3	3	3	3	3	3
Trigonometry	2	2	2	2	2	2
Analytical Geometry	2	2	2	2	2	2
Differential Calculus	3	3	3	3	3	3
Integral Calculus	3	3	3	3	3	3
Advanced Calculus	3	3	6	3	–	–
Physics						
Engineering	12	12	12	12	12	12
Chemistry						
General	8	8	8	8	8	8
Quantitative Analysis	4	4	4	4	4	8
Organic Chemistry	4	–	–	4	4	8
Physical Chemistry	4	4	4	4	4	8
Colloid Chemistry	–	3	–	–	–	–
Drawing						
Elementary Engineering	3	3	3	3	3	3
Descriptive Geometry	3	3	3	3	3	3
Geology						
Physical Geology	3	3	3	3	3	3
Historical Geology	3	3	3	3	3	3
Mineralogy, Cryst., Petrology	6	6	6	6	6	6
Petrology	–	–	–	–	3	–
Structural Geology	3	3	3	3	3	–
Stratigraphy	3	3	3	3	3	–
Sedimentology	–	–	3	–	3	–
Paleontology	–	–	–	–	3	–
Petrography	–	–	–	–	3	–
Geophysics	–	3	3	–	3	–
Mechanical Engineering						
Mechanism	3	3	3	3	–	–
Dynamics	–	4	–	4	–	–
Thermodynamics and Laboratory	6	6	6	6	6	6
Heat Engin. and Laboratory	–	3	–	3	–	3
Internal Combustion Engines	–	3	–	3	–	–
Machine Design	–	4	–	–	–	–

TABLE V

FOUR-YEAR CURRICULA IN PETROLEUM ENGINEERING

	Production	Development	Reservoir Engineering	Natural Gas Engineering	Geology	Process
	(Semester Hours)					
Civil Engineering						
Surveying	3	3	3	3	3	3
Chemical Engineering						
Fuels, Combustion, and Ht. Bal.	3	–	–	3	–	3
Unit Operations	3	–	–	–	–	6
Electrical Engineering						
A.C. and D.C. Machinery	4	–	–	–	–	4
General Engineering						
Engineering Mechanics—Statics	3	3	3	3	3	3
Eng. Mechanics—Kinet. and Kinem.	3	3	3	3	3	3
Strength of Materials	4	4	4	4	4	4
Hydraulics	3	3	3	3	3	3
Petroleum Engineering						
Introductory—Problems	3	3	3	3	3	3
Development and Production Methods	3	3	3	3	3	3
Laboratory	3	3	3	3	3	3
Valuation and Economics	3	–	3	–	3	–
Phase Relations—Oil and Gas Mixtures	–	–	3	3	3	–
Logging Methods	–	3	3	–	3	–
Natural Gas Engineering	4	4	4	4	4	4
Reservoir Mechanics	3	–	6	3	3	–
Design	3	–	–	–	3	3
English (and Public Speaking)						
Composition and Rhetoric	6	6	6	6	6	6
Technical Report Writing	3	3	3	3	3	3
Literature, Advanced ,Grammar, or Public Speaking	3	3	3	3	3	3
Miscellaneous						
U. S. History	3	3	3	3	3	3
Government	3	3	3	3	3	3
Totals	147	147	148	147	146	147

engineers of standing can look back and observe that their growth, technically and broadly as civic leaders, has been accelerated in a large degree by self-education outside the class-rooms. Recall the number of engineers who have attained additional proficiency in evening schools, discussion clubs, or, perhaps, through the

pursuance of training programs or courses of study promoted at company time and expense.

As Dean Hollister (2) concludes:

"No curriculum can or should aim to provide *all* the training necessary to the graduate in his subsequent life. It is impossible to say what his specific requirements of training will be. He *should*, however, be trained thoroughly in broad fundamentals. It is the duty of each graduate to adapt and apply these fundamentals to his needs as his life unfolds, and to supplement them with suitable additional study. The thorough study of fundamentals is least likely to be pursued on one's own, and hence should certainly be included in the curriculum. Subjects easily read by the average graduate student should be omittted from the curriculum; however, the teacher has a specific duty to inspire the graduate to such further reading."

It is, therefore, concluded that a petroleum engineering curriculum should emphasize:

1. Broad fundamental studies.
2. The role of design and economics as essentials in engineering.
3. Good English—in writing and speech.
4. Flexibility—realized through the proper choice of electives and elective sequences.
5. The importance of five-year programs in the development of versatility to meet the diversified demands of the petroleum industry.

Bibliography

1. Power, H. H., "Petroleum Engineering Education and the Quantitative Approach," Trans. A.I.M.E., Vol. 160 (1945).
2. Hollister, S. C., "Minimum Essentials of an Engineering Curriculum," Report Presented at Meeting of Regional Committee Members, E.C.P.D. Committee on Engineering Schools, Troy, N. Y., June, 1949.

Summer Schools

The Executive Board has approved the following Summer Schools which will be held at Michigan State College either before or immediately after the Annual Meeting in June, 1951:

Engineering Drawing—June 21–24, 1951

Humanistic-Social Studies—June 21–23, 1951

Mechanical Engineering—Thermodynamics—July 2, 1951 (for 2 weeks)

Mathematics for Engineers*

By M. E. SHANKS
Professor of Mathematics, Purdue University

Mathematicians often discuss the difficulty of teaching engineering students because of their persistent desire to see the utility of a new concept. Too often the conclusion is reached that little can be taught beyond a certain amount of routine technique. As a consequence, mathematics courses for engineers are distinguished frequently by a dead formalism and a paucity of connecting ideas between the various topics. At the present time there is sentiment for a change, and this sentiment stems in part from the engineering faculties in their search for greater mathematical competence for their students. While a reaction was certain to come, the recent war effort has so speeded up matters that it is now necessary to reëxamine our offerings to engineers in the light of current engineering problems and practices.

Consider the fact that a research engineer may be asked to tackle such difficult and diverse problems as the vibrations of non-linear systems, the flow of viscous or compressible fluids, and the electromagnetic fields of complex configurations. Clearly it takes considerable mathematical maturity just to comprehend such problems, and problems of the same order of difficulty are being encountered in increasing numbers, with the result that engineering schools are becoming more critical of the mathematical training their students receive. Critical appraisal of the mathematics curriculum will continue to be stimulated by the growth of graduate schools in engineering. Of course only a few engineers are engaged in research or go on to graduate study, but the point I make here is that early work in mathematics should be an adequate foundation for future study. Sad to relate, this is too often not the case; the engineer graduates without ever encountering any real mathematics.[1]

Status of Freshman Mathematics

Let us consider briefly freshman mathematics as it exists today in the United States, and, to limit the scope, confine our attention to state universities, where essentially all high school graduates are admitted. Two significant trends may be observed. One of these trends is the introduction of new terminal courses for non-science students, designed to fill a cultural gap. Such courses place little emphasis on the development of techniques and do not serve as a prerequisite for future work. The main objective is to convey some appreciation of the nature of mathematics and the problems it attacks, and to awaken interest.

The second trend is toward a more "unified" freshman course for the future scientist. Here, while cultural considerations are also involved, the main objective is to teach sound mathematics (and this means with proofs wherever possible) which is not separated into compartments of algebra, trigonometry and analytic geometry. The classical algebra, trigonometry, and analytic geometry sequence has had remarkable survival value. When one considers that it has been in existence for several generations without

* Read before the Indiana Section of the Mathematical Association of America, May 6, 1950.

[1] Obviously he is not alone in this respect.

essential change (except for some dilution in content) it is hard to imagine how such a fossilized entity could so long endure. Of all the sciences only mathematics has seen so little of modern concepts brought down into the elementary curriculum. We are surely ripe for a change. At the present time revised freshman courses are being attempted at various schools over the country but it is too early to predict at all what can be accomplished. However, emphasis on method, proof, and the introduction of unifying concepts are guiding principles.

If we admit that these objectives are desirable in courses for the pure scientist the question arises as to what to do for the engineer. It is first necessary to determine an absolute minimum that the engineer should learn. This minimum, I suggest, is a "good" grasp of functional relations and doubtless the same holds for the budding mathematician or scientist. If such is the case, it follows that all would-be scientists should take the same freshman course. Let us then examine in somewhat greater detail the content and procedures in the new freshman course.[2] As guiding principles perhaps the following suffice. (1) Teach less but more thoroughly. (2) Give clear statements of definitions and hypotheses with proofs by both instructor and student wherever possible. Difficult matters such as existence should be made plausible and then postulated. (3) Algebra, trigonometry, and analytic geometry should be taught as one subject, namely, analysis. (4) Introduce advanced ideas wherever profitable and natural.

Some specific suggestions would doubtless be pertinent in connection with such a program. The following are tentatively offered in extreme timidity but with hope. (1) Begin with the integers and review the elementary operations via a treatment of rational numbers; real numbers to be considered as decimals after a discussion of representations of rational numbers. (2) Use vectors (plane) in analytic geometry and introduce notions of vector spaces and linear independence. (3) Discuss continuity at an early stage and emphasize the intrinsic properties of functions. (4) Teach the properties of trigonometric functions in connection with a study of functions in general.

Since a guiding principle was to teach less but more thoroughly it is apparent that some rearrangement or deletion is necessary if the above specific proposals are to be followed. There are various ways to resolve this dilemma but certainly some of the classical material could be deleted. For example, the discussion of the conic sections might well be abbreviated, while the solution of triangles should be cut to a minimum. Of course some time would be gained by subsuming the study of the trigonometric functions in the general theory of functions. More important is the fact that since continuity (and perhaps beginning of calculus) would be covered in the freshman year it would be most natural to defer all of solid analytic geometry to the calculus course where it often has to be repeated anyway.

A Proposal

In conclusion, I would like to make a proposal for consideration by both mathematics teachers and engineers. It is a familiar observation that a large proportion of engineering students are not materially benefited by any mathematics beyond the most elementary calculus. Such students, and they are *not* necessarily inferior, might be described as those primarily interested in engineering practice, that is, design, production and sales.

[2] It is probable that calculus should, in part, be brought down to the freshman year, especially in connection with "analytic geometry" which as is taught at present is neither analytic nor geometry. In order not to get too involved I ignore this possibility here.

They are chiefly attracted by the final engineering product and may be found in all fields of engineering. On the other hand there is a sizeable group of students who may be said to be interested in engineering theory. It is proposed, therefore, that in the sophomore year the engineer begin to exercise an option, those with theoretical inclinations, or being undecided, to take a strong calculus course, the remainder to take an abbreviated, terminal course. Those taking the abbreviated course would, of necessity, concentrate in their upper class years on design and production while those taking the longer course could continue in either the direction of theory or practice.[3] Such a procedure would aid the teachers of both mathematics and engineering by presenting them with more homogeneous classes. Because of this probable salutary effect, a two-channel system seems to deserve serious consideration. I do not believe such a program would tend to lower standards in either mathematics or engineering, but quite the reverse, as it would permit solid instruction to precisely those students who are most interested in the particular course content.

[3] Naturally some revision of the engineering curriculum is involved too, but this is another story.

Graduate Training of Teachers of English for Engineers

By W. GEORGE CROUCH
Professor of English, University of Pittsburgh

Any program for the training of teachers of English for engineering students must be based on a realistic appraisal of existing conditions. Although much successful teaching of English for engineers is being done, the preparation of teachers for the important work of making our future engineers articulate and increasing their interest in literature and the humanities has generally been by trial-and-error procedure. As a result, we have had a few outstanding teachers and too many who have never risen above mediocrity.

Difficulty of Obtaining Suitable Faculty

One reason for this state of affairs is that colleges and universities have found it difficult to get the right kind of men for the job. I believe that I am safe in saying that the average teacher of English prefers to work with English majors and liberal arts students rather than with preprofessional students. During his work in the graduate school, he has been trained in scholarly methods. He has usually had courses in philology, Old English and Middle English, seminars in English and American literature, and specialized study of at least some of the great literary figures of the past. He has been shown how to collate manuscripts, edit texts, write competent introductions to texts, make glossaries, and use bibliography. After his graduate training, he is eager to communicate at least some of his hard-earned knowledge to advanced students —preferably to other graduate students in English.

The young Ph.D. probably realizes that he will have to go through a period of apprenticeship before he will be admitted to a graduate faculty. His ideal of ultimate success is usually to belong to such a faculty and to publish monographs and articles in the area of his special interest. He also hopes to teach elective courses—courses which will allow him to broaden and enrich his understanding of the periods and figures of literary history which attract him. During his apprenticeship, he will probably have to teach some English composition to engineers or other preprofessional students, but he will tend to look upon this part of his schedule as necessary drudgery until he has made his mark by publication.

Rewards for teachers of English do not come by way of the monthly check, for salaries are usually only moderate. The teachers' greatest rewards stem from their opportunity to work in their chosen field and to communicate their scholarly enthusiasm and methods to young people who have interests in harmony with theirs. Few men, therefore, consider making a career of teaching English to engineering students. Many of them look upon such teaching as academic suicide.

The young teachers who, whether by accident, or choice, are assigned schedules made up only of sections of engineers soon find that they have lost caste with their colleagues in the Department of English. These colleagues tend to look upon them as inferiors, or they offer their sympathy, or they gloat because they are assigned liberal arts students while their hapless brothers have to wrestle with the problems of the engineers. Because of this attitude—implied or openly expressed

—the young teacher of English begins to regard his sections of engineers with distaste. His teaching becomes a task instead of a joy. And he aims to get out of such a situation as soon as he can.

Teachers of English in other institutions are also likely to consider the man who directs "English for engineers" as an unfortunate being. They feel that perhaps he is unable to meet the competition in his field; otherwise, he would not be restricted to the rather elementary job of handling only engineering students.

If the instructor of engineers takes his work seriously and enthusiastically, he will have to spend so much time in preparation and the marking of papers that he may be forced to neglect research. His classes are most likely to be in composition. They will not lead him to do broader reading in such traditional subjects as Elizabethan literature or Milton. Certainly, the opportunity to do research in language or literature is not so great if the teacher has to devote himself to the problems of the engineering student as it would be if he were dealing with English majors or advanced students in the College. And most administrators demand that their staff publish frequently as a prerequisite to promotion.

Attitudes of Administrators

College administrators may—and often do—regard teachers of English for engineers with some suspicion. They may question the versatility of a teacher who is limited to such a narrow field. They may promote him more slowly than they promote his colleagues. They may use his restricted kind of teaching as an excuse for keeping his salary at a lower level than that of men who do the more spectacular work in the Department of English—the men who lecture to 200 students in a Shakespeare course or those who attract large numbers by their brilliant exposition of the Romantic poets.

These attitudes are more common in liberal arts colleges and universities than they are in the technical institutes. Departments of English in such institutions exist chiefly for the engineers, and teachers in departments of this sort know that they will be judged mainly by the effectiveness of their work with technical students.

In the liberal arts colleges and universities, moreover, it is not always possible to get the best men in English to teach engineers. Some English departments send only their very young teachers—the graduate assistants (sometimes called lecturers) and instructors—to do this kind of work. Sometimes they demote unsatisfactory men by making them teach the engineers. Sometimes, if they cannot give their promising young teachers quick advancement, they use them in engineering service courses only until they can place them advantageously in the more specialized English courses in the College. As a result, a large number of English teachers are either not in sympathy with the aims of engineering students and engineering education, or they resolve they will make the best of a bad situation until they can be given teaching more to their liking. In any event, the engineering student suffers.

Most deplorable, too, is the fact that this kind of English teacher never bothers to acquaint himself with the work the future engineer will be called upon to do. He neither understands his students' problems nor their technical vocabulary. He is indifferent to their needs. Quick to perceive such a situation, the student himself builds up an antagonism toward his English teacher. He is hardly to be blamed if he considers that he dwells in a world apart, and that English as a study is far removed from his interests as an aspiring engineer.

Solutions to Problem

What can be done about this problem? First of all, colleges of liberal arts and universities should strive to employ men who have had training in both engineering and English as teachers for engineering students. Such men will have much in common with their students, for they will be men who have taken a general engineering course and who will also have demonstrated their skill in expression and

their knowledge of literature. Having had engineering training themselves, they will know the language of the engineer. This will enable them to read his work with understanding. They will also be able to sympathize with his aims. They will have, too, some knowledge of what engineering education attempts to do.

Men of this caliber have done distinguished teaching at the University of Pittsburgh. Three of our young men who teach English to engineers have degrees in engineering. All of them have had at least one year of graduate work in English in addition to a minimum of eighteen credits in English which they took as undergraduates. They make enthusiastic instructors of engineers because they are devoting themselves to the kind of teaching which they like. Although they know they may never teach such courses as the history of English drama or seventeenth century poetry and prose, they are satisfied. Their aim is to help the engineer express what is within him and to give him a social-humanistic point of view. Yet we do not have in Pittsburgh—or anywhere else, for that matter—the kind of graduate training in English which will help them to prepare themselves most efficiently for this highly important task.

If we are to train the right kind of men as instructors for engineers, we must set up a different sort of graduate program in English. I am by no means suggesting the complete elimination of our traditional graduate training in language and literature. The man who is to deal with engineering students, for instance, should have a detailed knowledge of the history of the language. Unless he understands its growth and structure he will be handicapped in the classroom. Yet he will not need as many courses in philology as the man who expects some day to direct graduate students. The teacher of English for engineers should have a comprehensive background in literature, but he need not spend as much time on research problems as the man who intends to make literary research a primary goal or who will have to expound methodology to graduate students. The future teacher of engineers should be comparatively free from courses which would aim to teach him textual criticism or editing. Instead, he should be required to have a broad reading background in English and American literature and a sensitive appreciation of literary values. He should know the important writers thoroughly. And he should also be well acquainted with contemporary literature, for his engineering students will be vitally interested in the literature of their own time. If the teacher himself is ignorant of that literature or has only a superficial acquaintance with it, he can not expect his students to respect his professional aptitude.

This kind of graduate training should emphasize the production of teachers rather than research scholars. There should be at least one seminar devoted to a discussion of teaching and its techniques. The future teacher should know how to communicate his knowledge most effectively. This means that time should be spent on the methods of teaching composition and literature. A seminar aiming to do this should be conducted by the most successful instructors of English for engineers.

To supplement work in this seminar, students should observe experienced teachers of engineers. Beginners can learn much from seeing successful teachers in action. And they should have a chance to talk over teaching methods and devices with the older men. The give and take of free discussion will help the seasoned professor as well as the neophyte.

Good Teaching Traits Are Most Essential

But merely knowing techniques and observing older teachers will not be enough to guarantee that the graduate student should, upon receiving his degree, be turned loose in the classroom. During his graduate training, he should be allowed to do some actual instructing. Each supervisory professor should have two or three graduate students to direct. Several times during a term he could turn over a lecture or a discussion period to one of his students. It should be his duty

to observe the student carefully, to note what he does best, to catch weaknesses whenever they are apparent, and to talk over the results of his observations with the student-teacher. Above all, he should be able to judge whether the student demonstrates a sound background of knowledge, and enthusiasm and skill in communicating that knowledge. Sympathetic and helpful criticism would do much to produce the kind of teachers needed for engineering students.

The supervisor should also be quick to detect the incompetent candidates. He should be firm enough to recommend that such people should not go on with graduate study leading to the instruction of engineers. If we are to have the kind of teaching which will be truly inspiring, we must set up a system which will prevent the unfit from using the profession as an easy way to make a living or as a stepping stone to another and perhaps more lucrative career.

It would be well, too, if candidates could be brought into contact with teachers of engineering subjects. Such teachers could occasionally be invited to the seminar dealing with methods. They might outline their aims and their own teaching devices. In this way, the future teacher would be broadened in outlook and would also be made to feel that the faculty of the School of Engineering has an interest in him.

I hope I have not given the impression that I want such graduate training to emphasize methods to the extent they are stressed in Schools of Education. I am convinced that a deep insight into subject matter is more important by far than methods of presentation. The excellent teacher will have his own inimitable method. The tyro, however, can be aided materially during his early years by knowing what devices have proved successful and by being forced to think for himself about the best ways to communicate to others what he knows. The actual study of methods should never be permitted to assume primary importance in any graduate program for teachers of English for engineers.

Implications of Such a Program

A program of the sort outlined would be expensive. The English teacher with engineering training would have to be paid more adequately than our present group of English teachers for engineers. The salary scale applicable to his work would have to be that of the School of Engineering rather than of the College of Liberal Arts. He should be able to feel that no distinction is made between his usefulness and that of his engineering colleagues.

Such a program would, I believe, give to engineering schools the kind of English teacher they have always wanted but have not often been able to obtain. He would have a live interest in engineering as a profession because he himself would have an engineering background. He would be close to the interests of his students, and could command their respect because of his technical knowledge and acquaintance with their language. He would be a more efficient teacher of English because he could criticize intelligently the kind of writing which every engineering student has to do.

Likewise, his specialized training in English language and literature would supplement his knowledge of technology. He should be able to show his students their obligation to be cultured and intelligent citizens as well as proficient engineers. He should be able to give them catholicity of taste in reading, respect for exact use of language, and knowledge of how to handle those forms of writing applicable to the work of the engineer. His own comprehensive reading background, general culture, and skill in teaching should make him an ideal to be emulated. And his alliance with the engineering profession should eliminate any diversity of aim between the teacher of engineering subjects and the teacher of English. Both would be working towards one goal: the shaping of men who will be intelligent citizens, conscious of their obligations and responsibilities to society first of all, as well as soundly trained engineers.

The Influence of Production Processes on Design*

By EDWARD N. BALDWIN

George Westinghouse Professor of Production Engineering, The Pennsylvania State College

A designer has always been governed by the equipment and the process to be used in creating the part he is designing. The skillful Greek and Roman artisans were limited to simple stone and woodworking implements, while today we have many tools, processes, and materials from which to choose. The field has expanded so rapidly that the designer cannot expect to be sufficiently familiar with these processes in order to use them effectively.

The wide interest in the relationship of processes, materials, and design is shown by the volume of current articles available in such publications as: *Machine Design, Product Engineering, Materials and Methods,* and *Mechanical Engineering;* and in books such as Roger W. Bolz's book, *Production Processes and Their Influence on Design,* and *The Tool Engineer's Handbook.*

Since information on this subject is practically limitless, our discussion will be confined to: (1) a few examples of specific processes to illustrate their influence on design, or the design's influence on the process and the evident principles and reasons for their use; (2) a consideration of these processes from the viewpoint of training engineers to consider their possibilities in reference to their designs; and (3) some fundamental principles which often occur in similar processes.

The Designer

The designer of today controls the production of his part by issuing manufacturing specifications based on drawings. The relation of equipment and processes to design is illustrated by the drawing of a part. This drawing controls equipment and the processes required to make the part; the form of the part determines whether it is to be bent, drawn, stretched, or rolled; the machining specifications on the drawing determine the kind of machining—drilling, milling, boring, broaching, or grinding; and the material description determines the form of raw material—casting, forging, or bar stock, which in turn determines the selection of the fabricating processes.

Thus, a designer cannot effectively design a part unless he knows how the part is to be made. The effective designer must have a knowledge of the cost of materials and processes and equipment and their advantages and limitations, such as tolerances and range of sizes. He must use ingenuity in their application and have a thorough knowledge of the principles underlying a wide range of materials, processes, and equipment. When all the processes in industry are surveyed, it is apparent that it is impossible for the engineer to know the entire field. However, it is profitable to understand the underlying principles and possibilities of some of the processes and materials which can be applied to the parts created in the design. The methods and procedures for analyzing the processes and materials and determining the suitability of their application to the design can be used by the designer in any industry.

Stress Strain Diagram

The stress strain diagram is familiar to every engineer and therefore it is used as an example of how fundamental information can be used to understand and il-

* Presented before the Mechanical Engineering Division at the 57th Annual Meeting of the ASEE, Troy, New York, June, 1949.

lustrate the relationships of materials to processes and design. These related factors—when known—provide an insight into the reasons for the performance of material during the process. The production engineer who understands and uses this type of fundamental information is a more effective designer.

The Material Testing Laboratory may be used as an example of how closely related factors can be used with greater effectiveness by the designer. The first test usually made in a Materials Testing Laboratory is a tensile test. From the test data a stress strain diagram may be drawn. The shape of the curve indicates the elastic limit, the yield point, the maximum and the ultimate strengths, which can be found in various handbooks and standard data. However, let us look at the additional facts that can be learned from a stress strain diagram concerning processes and their use in design. In Fig. 1, Curve (1), it is known that if the load is released at any point on the curve before the material breaks, the points will take a path back to zero load on the straight portion of the curve, or essentially parallel to the straight portion of the curve if the load is released on the curved portion. The latter condition shown by Curve (2) will indicate to the engineer that the material cannot return to its original state and we say that it has a permanent set. He will see that if the load is reapplied, the points will fall on the dotted line, Curve (2), until the curved portion of Curve (1) is reached again and continues on Curve (1). Thus, we have different physical characteristics in material indicated by Curve (2). The elastic limit has been increased. By using the same factor of safety, the material can be designed into a part requiring greater applied loads.

Instead of plotting the total load in pounds alone, suppose he is asked to plot the load per square inch of the actual area. The results of some tests indicate that the load then would approach a straight line Curve (3). These straight lines, Curves (2) and (3), serve the purpose of illustrating what occurs in a certain group of processes. Can the reader

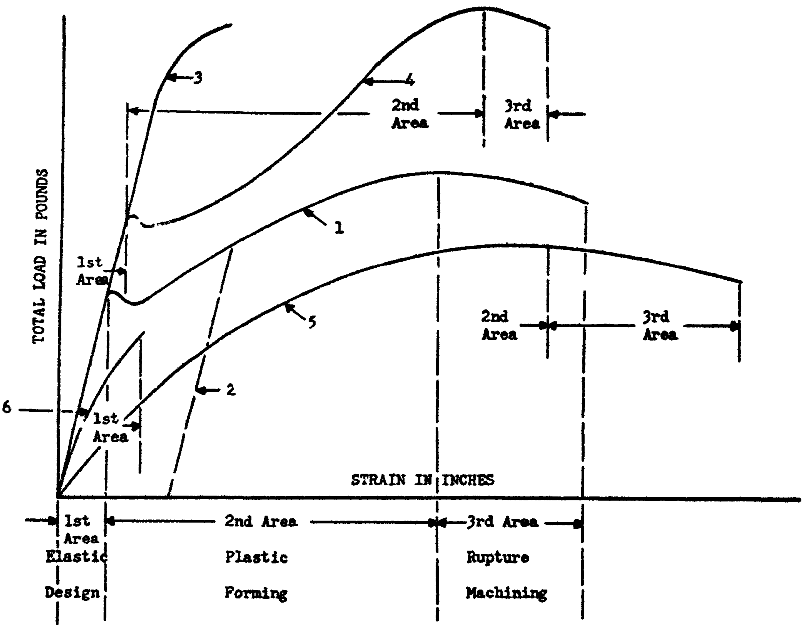


FIG. 1.

name and describe the processes of manufacture illustrated by the test? Such a study will bring clearly to mind the relation of stretching to the various types of manufacturing processes. These processes would include draw-, bench-, and roll-straightening; stretch forming sheets, bars, angles, pipe, and wire; stretcher-levelling sheets; and the drawing of angles, hexagons, squares, and rounds.

Important operations within industries use this principle to straighten and strengthen parts. For example, the wire which passes through the glass portion of the radio tube is of a composition different from the wire supporting the elements within the tube. A machine has been developed to butt weld firmly together these fine wires, made of two different materials, stretch the wire after welding to give a straight, strong, and stiff wire and then cut the wire to the proper length. This operation can be seen in any lamp or radio tube manufacturing shop.

The A. O. Smith Corporation took the leadership in oil and gas pipe manufacture through their development of equipment to make pipe that was straight and round, and stronger per pound of material than any other make. The fundamental principle of stretching is used in the final operation. After the plate is trimmed to size, formed, flash welded, and the welding flash trimmed, it is placed into a steel cylinder having the required inside diameter. End plates are placed on each end and the pipe is filled with water. Then a high hydraulic pressure is applied and the pipe is forced to the size of the cylinder and thus stretched to size, straightened, tested, and strengthened all in one operation.

In the future, the young engineer may have a part which requires more strength or straightening, and if he remembers the principle of drawing and stretching in the testing laboratory, he may be able to solve a difficult design problem.

The effects of cold working or cold drawing can be illustrated by partially sawing or machining a cold-drawn bar and noticing how the bar distorts. The release of internal strains is the answer to why this distortion occurs, and will explain the behavior of many materials when machined or processed. Through such analyses the production engineer will soon acquire the ability to picture in his mind what occurs within the material during the various processes. The use of rubber, plastic material, stress points, and gages in the experiments with models enables the production engineer to solve difficult problems and obtain an efficient and economical design.

Let us consider the diagram under Curve (1), Fig. 1, as a whole and note that there are three main areas which are related to design and manufacturing processes:

First Area

The first area to consider is under the straight line portion or the elastic range of the material. In this area the student uses the theory of mechanics, strength of materials, machine design, graphical analysis, safety factors, and fatigue. Parts are designed within the scope of this first area so that they will not distort and fail in service. There are very few processes, such as press and shrink fit, that work in this area under the straight portion of the curve. When designing in this area, often the engineer makes the error of giving very little thought to the second area wherein the material is strained beyond its elastic limit during manufacture.

Second Area

When the part is designed and detailed on the drawing, it is turned over to the men of the manufacturing department, who determine the means of forming and machining the part. The work under the second and third areas of the curve. This curved portion of Curve (1) is of extreme interest to the manufacturing engineer and it should have the same interest for the design engineer. The shape of the curved portion of the material curve indicates how the material will perform in the various types of forming processes. A steep Curve (4) indicates work hardening with resulting poor bending, drawing, and forming qualities. The material will

require frequent annealing to prevent cracking and straightening after forming because of excessive spring back. The shape of Curve (5), on the other hand, indicates a yielding material which would be excellent for drawing and forming.

Third Area

The third area is between the maximum load and the breaking point of the material. Machining and shearing operation characteristics are indicated by this area. Curve (6) for cast iron indicates a machining condition different from Curve (1) for low-carbon steel. When a material is machined, each particle goes through a similar path—first strained within its elastic limit, then stretched beyond its elastic limit, and finally broken off. Curve (6) for cast iron has no curved portion, indicating that the machining would be brittle. In contrast, the length of Curve (1) for low-carbon steel indicates that the machining characteristics would be tough and stringy.

The Test Laboratory Can Illustrate Theory and Practice

Coming back to the test laboratory, it can now be seen that the tensile-testing machine can illustrate the fundamental principles underlying the forming processes and why and how the materials react to these processes. The same testing machine could be adapted to illustrate deep drawing, bending, spring back, wire drawing, straightening, stretch bending, cold upsetting, coining, stretcher leveling, the effects of annealing, and other forms of heat treatment.

A material-testing laboratory could be set up on a straight-line basis. The student could start with a set of samples of the same material, putting each piece through a different process, including heat treatment, and measuring the effect on hardness, tensile strength, elastic limit, ductility, and, at the same time, could study flow of the material. He could obtain relative values of machinability, work hardening, and fatigue strength; check the parts with magniflux and X-ray; make a notch and fatigue test; compare shearing strengths, and use stress paints. By studying one material thoroughly, such as a particular grade of steel, his insight into the relations of the process to the material and its composition could be well understood. Comparative demonstrations on other materials could be made by the instructor to illustrate how these materials would fit into the processes.

The instructor could constantly call the student's attention to what is going on inside the material as it is being processed on the laboratory equipment. For example, the answer to the question—why the stretch bent part does not spring back but takes the exact form of the die—can be explained by the stress-strain diagram and an analysis of the stresses within the member as it is bent and then stretched. The visualization of the stresses within the increments making up the whole part can be revealed by the analytical approach to the problem. The approach used in solving any engineering problem of stretch bending can be applied to any process that stretches the material. Thus the student would be vitally interested in strength of materials courses because he could see the principles used in industry.

Competition Between Processes and Materials

There is no one best process or material. The choice of processes or materials depends upon many factors which vary from day to day. The most economical material and process may be chosen today; and tomorrow changes in the cost of labor or material, quantity to be manufactured, or equipment will make it economical to manufacture the part from another material or by a different process. There is intense competition between processes; and when the engineer chooses his materials and process, he must be sure the choice is the most economical in the long run, or competition will forge ahead. Cast steel *vs.* steel forgings, plastic parts *vs.* die-cast parts, stamping *vs.* castings, precision casting *vs.* machining and grinding, milling *vs.* broaching, turning *vs.* grinding, welding *vs.* casting, all illustrate such competition. The extent of the engi-

neer's knowledge of materials and processes determines the value of his judgment in deciding how to make the part. Therefore he should be alert to every form of information available.

The Value of Equipment and Processes in Relation to Design

The importance of the influence and value of processes and equipment can be illustrated by the induction motor. Figure 3 shows the reduction in weight and size of a 5-hp. motor over a period of 60 years. It can be seen that very little progress in the reduction of weight (6.8%) and size (11.5%) has been accomplished in the last 17 years. Therefore, there was not much chance of reducing costs by reducing the amounts of the same materials. Any reduction in cost had to come from improvement in the processes and equipment used in the manufacture of the motor. When the processes and equipment are improved on the new silicone motor, which uses new material, prices also will come down. The Westinghouse Life Line Induction Motor is an excellent example of the close coordination of the process of manufacture with design. The manufacturing and design engineers made many improvements in the detail parts, but two outstanding savings were made in assembly. Though assembly is not ordinarily considered as a process, it is a most lucrative field for cost reduction and is controlled by the designer to a great extent.

1. The assembly of a motor was simplified by reducing the number of parts necessary to make the many combinations required by the customer. There are more than 30,000 standard combinations of a 5-hp. motor that a manufacturer has to supply. Formerly 2800 parts were required to build these combinations, but through the cooperation of the designer and manufacturer, the number was reduced to only 126 parts.
2. The manufacturing and design engineers, by combining theory and shop practice, adopted an improved shape of slot to hold the stator windings and enabled the windings of a 5-hp. motor to be assembled in ½ hour as compared with 2½ hours on the previous designs.
3. The assembly costs were reduced and performance was assured by the use of precision processes and strict controls to obtain accurate sizes of parts at a few vital points. For example, the precision boring of the ball bearing housing assured the successful application of anti-friction bearings. (The subject of process control and its influence on design is worth careful consideration.)

The story of the Life Line Motor is an excellent case history illustrating the value of the influence of processes on design, or design on processes; it is hard to determine which came first.

STANDARD 5 HP. INDUCTION MOTOR

Year	Weight	Difference		Diameter	Difference		Cost to Customer		Index
		Lbs.	%		In.	%	Actual $	1926 $	1926 =100
1897	1000 lbs.			30 in.					
1900	640 lbs.	360	36%	21 in.	9	30%			
1905	210 lbs.	430	67.2%	15 in.	6	28.5%			
1914							59	86.5	68.1
1930	147 lbs.	53	25%	13 in.	2	13.5%	69	80.0	86.4
1945							66	62.8	105.8
1947	137 lbs.	10	6.8%	11½ in.	1½	11.5%	101	66.8	151.8
1949							106	65.0	162.0

Silicone Insulated 5 HP. Induction Motor

Glass and silicone insulated motor using high temperature grease in ball bearings illustrates the influence of change in materials. Their cost is high because time has not permitted the complete development of the various processes.

1949*	90 lbs.	47	33.6%	9½ in.	2	17.4%			

* These are conservative figures. It is possible to obtain 7½ hp. in these sizes, but labor is too expensive to justify the smaller frame.

Material and Labor Costs
1939 vs. 1948

In spite of increased costs engineers have made improvements in design and processes and used them effectively to give the customer more value.

	1939	1948
The hourly rates of employees are	100%	190%
Material cost	100%	176%
Sales price of product	100%	138%
Profits per sales $	6.9¢	5.7¢

Teaching Processes

Processes become simplified when approached from the viewpoint of the designer. The history of development, the various types, styles, and makes of machines and how they are operated become incidental. The young engineer needs to know the operation performed, the range of sizes and capacity, previous and subsequent operations, the cost of operations, the extent of skill required, the quality achieved, and the ability to maintain the quality desired. He should see the principle of the process used to enable him to visualize its application to his designs. The best possible instruction can be given through a visit to a plant where the operation can be observed. The design of a part made by the plant could be given as a problem; and, after the students have selected the material and the process, they could then observe the actual manufacture and possibly discuss the part with the production engineer in the company.

Conclusion

In conclusion, the close relationship of production processes, materials, and design should again be emphasized. Class, laboratory, shop, and case history instruction should keep this relationship before the students at all times. When the student uses the information on processes and materials in creating his design, he usually becomes interested and pursues his design problems with enthusiasm.

Progress Report on Accident Prevention in Engineering Schools*

By JOHN J. AHERN

Professor and Director, Fire Protection and Safety Engineering
Illinois Institute of Technology

Your Committee has been encouraged by the substantial progress made in the industrial safety field by engineering schools in the past five years. A great step forward was the Conference of Engineering College Administrators and Professors held at Georgia School of Technology in August of 1948.

This conference at Georgia Tech was designed to assist engineering schools in initiating action on industrial safety on their campuses and to make a start on the inclusion of work on accident prevention in their curricula. Sponsored by the Committee on Cooperation with Engineering Colleges of the American Society of Safety Engineers, this conference stressed a three semester hour course which had been carefully prepared by the Committee. Seventeen engineering schools participated in this conference, and of this number fourteen are now offering courses in Industrial Safety and reporting an active participation in this work by their students.

A second conference was held for Midwestern engineering schools in May 1949 at Illinois Institute of Technology. Twenty-one schools participated in this second conference, and although only a year has elapsed reports indicate that at least fifteen schools are now offering courses in Industrial Safety and all report an active participation by the student body.

A third conference was held at Texas A. and M. in January 1950. Although it is too soon to appraise the results of this last meeting, it was well attended by approximately fifteen engineering schools from the South and the South-West, and we expect good results from this section of the country.

This program of conferences has made it clear that all engineering schools will see the need for some work in this field, not for the purpose of producing safety engineers but to prepare all engineers to meet the difficult safety problems presented by modern technology.

The work which has been done indicates that a sound program may be built by first establishing an elective course in the fundamentals of accident prevention for junior or senior students. As interest develops on the campus considerable attention will be given to the integration of safety principles into other engineering courses. Some students, few in number, will be attracted to the field of safety engineering and a program leading to a M.S. degree can be substantiated.

A resume of the work now going on in the schools participating in the first two conferences is listed below.

* Presented at a Conference of Industrial Hygiene, Safety and Fire Prevention Committee of the ASEE, University of Washington, Seattle, Washington, June 22, 1950.

GEORGIA TECH CONFERENCE

Texas A & M College	Dean H W Barlow	At present offering a three-hour Safety Course patterned after the ASSE outline
University of W Va	Prof H N Cather, Head of Mechanical Eng Dept	At present offering a course practically the same as outlined in our pamphlet and listed as E M 117 Attendance in course averages about 25 and includes students of various engineering departments
Alabama Polytechnic Institute	Prof C N Cobb Head Dept of Industrial Management	The three-hour Safety Course for Engineering and Management students which has been offered for a number of years has been adjusted in light of ASSE recommendations, and the time allotted per week has been increased to five hours
University of Kentucky	Mr O W Gard, Dept of Mechanical Engineering	Now offer a Safety Course which carries two semester-hour credit on an elective basis Endeavoring to expand the number of students and to have this course required for at least students in Mechanical Engineering Also offering three courses in fire protection and integrating safety into tool design and machine design on a small scale.
North Carolina State College	Prof D E Henderson, Head, Dept of Industrial Engineering	They are at present offering a three-hour course similar to ASSE outline and the prospect is that an additional section will have to be offered each term
University of Oklahoma	Prof R V James School of General Engineering	No course if offered at present, but several have been approved and are awaiting the availability of staff men
University of Tennessee	Prof Robert M LaForge, Dept of Industrial Engineering	At present they have a course similar to ASSE outline which is being taught in the regular sessions and required for graduation in the Industrial Engineering curriculum However, other engineering departments have contributed about one-half the enrollment A similar course has been taught using the ASSE outline in Extension, at several points in the Univ of Tennessee area A faculty safety committee has been appointed to check hazards and working conditions
University of Miami	Prof M I Mantell, Chairman, Dept of Civil Engineering	Many immediate problems arising out of the development of this relatively new engineering school have delayed plans for their separate safety courses. Safety Engineering lectures are being included in C E 410, Contracts and Specifications, which Prof. Mantell presently teaches.

Purdue University	Dean A. A. Potter	Offering a three-hour course which has been adjusted following ASSE outline to accommodate the Engineering and Management students from the course which they have offered for a number of years in the past.
University of Illinois	Prof. M. A. Parker, Head, Dept. of Mechanical Engineering	Basic safety course is presently being offered.
Missouri School of Mines	Prof. D. R. Schooler, Department of Mining Engineering	Offering a basic safety course.
Iowa State College	Prof. J. K. Walkup, Head, Department of General Engineering	The Industrial Safety Course has been modified so as to be similar to the ASSE outline. The principal exception is the inclusion of six sessions on Workmen's Compensation and Safety Laws and the insurance of employers' risk under these laws. Some integration of Safety has occurred in designed courses in EE, ME, and CE, as well as the IE Plant Layout Course.
Clemson College	Prof. F. C. Mills	No report.

Illinois Tech Conference

University of Nebraska	Prof. Niles H. Barnard, Chairman, Mechanical Engineering	Offering a three-hour course in Safety Engineering for senior engineering students. Present enrollment of 37 including several business administration graduate students.
University of Cincinnati	L. B. Chenoweth, M.D., Director—Dept. of Hygiene	Dean of College of Engineering is considering offering a basic safety course.
Rose Polytechnic Institute	E. H. Eckerman, Asst. Prof., Mechanical Engineering	No report of activities.
Northwestern University	Stanley J. Seimer, Instructor—Industrial Management Dept.	Some use has been made of safety material in other courses. No basic course has been offered.
University of Louisville Speed Scientific School	H. H. Fenwick, Associate Prof., Mechanical Eng.	No report of activities.
University of Kentucky	Oliver W. Gard, Instructor—Dept. of Mech. Eng.	Offering three courses in fire protection —2 semester hours each—also one course in industrial safety—2 semester hours.
University of Akron	Fred S. Griffin, Head, Mech. Eng. Dept.	Offering a two-credit hour safety course in the Industrial Management Division —also integrating safety in Mechanism and Machine Design courses.

University of Wisconsin	O. A. Hougen, Prof., Chemical Engineering	No report of activities.
University of Minnesota	J. L. Imhoff, Prof., Mech. Eng. Dept.	Offering an Industrial Safety Course as a part of the Industrial Engineering Sequence.
Fenn College	Chester J. Kishel, Ass't. Prof., Dept. of Mech. Eng.	Offering 3 hour course in Industrial Safety in Mechanical Engineering Dept.
University of Denver	C. M. Knudson, Dean, College of Engineering; Prof. J. E. Baylor, In Charge of Safety Engineering Course	A one hour course in safety is required of all engineering students. This is followed by integration of safety in departmental courses.
University of Chattanooga	Norbert Koch, Ass't. Prof., Engineering	Offering a three-hour course in Safety in Industrial Engineering, Industrial Management and General Engineering at the senior level. Will probably break it into two courses soon.
Purdue University	O. D. Lascoe, Associate Prof., Manufacturing Processes	Offering a three-hour course in Industrial Safety averaging about 40 students each semester.
Michigan College of Mining and Technology	George M. Machwart, Associate Prof. of Chemical Eng.	Course was recommended but has not been offered to date.
School of Mines & Metallurgy University of Missouri	D. R. Schooler, Assoc. Prof., Dept. of Mining Engineering	Offering one two-hour course in safety which is required for all mining engineers. Another two-hour course is an elective for all engineering students. In addition a three-hour advanced course is offered.
Wayne University	Rex H. Schoonover, Asst. Dean—Engineering	No report of activities.
Columbia University	Wm. W. Waite, Assoc. Prof., Industrial Eng.	Offering one three-hour course in Industrial Safety.

Sponsoring Schools

Illinois Institute of Technology	John J. Ahern, Prof. and Director, Fire Protection and Safety Engineering	Offering a full four year program in Fire Protection Engineering since 1903. Offering a series of Industrial Safety courses for all engineers at junior and senior levels in addition to work in graduate school.
Georgia School of Technology	Wm. N. Cox, Jr., Prof. and Head, Dept. of Safety Engineering	Offering a series of Industrial Safety courses at junior and senior level for all engineers. In addition work is done in graduate school at M.S. level.

Ohio State University	Paul N. Lehoczky, Chairman, Dept. of Industrial Eng.	Offering series of Iudustrial Safety courses for all engineers and also a graduate program at M.S. level.
University of California at Los Angeles	J. H. Mathewson, Lecturer in Engineering	Integrated program in safety with both an undergraduate and graduate program. Specific Safety Courses are offered.

It is recognized that any such compilation must of necessity be obsolete as soon as it is released because there will be additional activity taking place in many of these schools. For additional information on safety courses you may obtain a copy of a summary compiled by the National Safety Council by writing to this organization at 425 North Michigan Avenue, Chicago, Illinois.

The progress made specifically in Engineering Colleges is due to a great extent to the outstanding work of J. C. Stennett, Chairman of the Committee on Cooperation with Engineering Colleges, American Society of Safety Engineers, and the close cooperation between the members of his committee and the members of the Industrial Hygiene, Safety and Fire Prevention Committee of the American Society for Engineering Education.

We all know educational advancement comes slowly, and we have made an excellent beginning in this rewarding new field that pays off in lives saved and increased efficiency in operation and production. There is much to be done towards improving our methods—but if we educators do our part it will not be long until accident prevention becomes an integral part of the background of all engineers.

Respectfully submitted,
John J. Ahern, *Chairman*

W. N. Cox, Jr. — W. F. O'Connor
G. H. Dunstan — N. A. Parker
D. E. Henderson — J. K. Walkup

Helping the New Graduate Choose His Employment

By D. W. McLENEGAN

Staff Assistant, Technical Personnel, General Electric Company, Richland, Washington

It is reported that over 4000 employers sought to hire the 32,000 engineering graduates of 1948. Some of these employers wanted one or two men, others were looking for hundreds. They all wanted men who "had what it takes" but their individual needs, job requirements and opportunities varied widely. The list included manufacturers large and small, utilities, processors of raw materials, contractors, service industries, government, and others. Some sought a man to fill an immediate job, others offered substantial training programs to orient young engineers before specific placement.

Even before the war, conscientious professors and placement advisors were hard put to provide their students with a clear approach to these complexities of industry. Today the burdens of teaching are heavier, the graduating classes are often too large to permit intimate acquaintance with each student, and new industries are presenting new demands. How shall a counsellor give his boys a preview of industry, or help each one fit his talents to the right kind of employment?

In interviews with engineering students shortly before graduation, it is usual to inquire as to each man's interest, and to try to uncover the reasoning back of his choice. The reasoning is often more significant than the student's specific choice, since his preferences will probably change as he gets better acquainted with industry. Naturally, the interest of most students is linked closely to some product or study with which they are acquainted. The typical Navy veteran wants "communications" or "power plants," in line with his experience. The younger student who missed war duty may want "gas turbines" if his courses in thermodynamics have aroused his interest.

Only a few seem to have clearly in mind some *function* they would like to perform in any enterprise, be it "communication" or gas turbines." Still fewer have given much thought to the qualifications needed in the various functional fields. Nor do they appear to realize that a few major job functions can be traced through many industries whose end products differ widely.

Major Functions in Industry

Here, then, may be an approach to simplified job counselling. We can postpone any detailed comparison between the many specific jobs until the major functions of industry are clearly understood. A good mechanical engineer can be equally at home with gas turbine, diesel, or air conditioning development, since they all depend on the fundamentals of dynamics, thermodynamics, fluid flow and heat transfer. He does not need to choose his exact spot in advance. Likewise, the art of a good sales engineer, like that of the actor, goes beyond the specific product or vehicle. And the principle holds in the supervision of manufacturing; skill in human relations

and in evaluating business expenditures, plus a knowledge of fabrication processes, can be focused on the specific problems of almost any production process.

We can therefore direct the young engineer's attention first to the broad activities by which industries seek to earn a profit, and then to the principal qualifications required of men in these activities. Although these principal functions may be sub-classified in many ways, the major ones may be stated simply:

1. Creation of useful new products or processes, and the improvement of existing ones. These are the real objectives of development and design engineering.
2. Production by processing or manufacture, including responsibility for plant and production facilities.
3. Marketing—including market analysis, sales planning, application and sale of products, installation and servicing,—the whole process by which products reach the user and are matched to his needs.
4. Accounting and financial analysis of the operations listed above—a field which can use more men with combined technical and business education.

These four headings are broad enough to cover the major functions, whether a company produces electric power, oil, chemicals, electro-mechanical products or offers and engineering service to others. Further headings might be added, such as patent law or employee relations; but most of the engineers who enter these fields do so only after some experience in one of the principal operating functions.

Not all industries place equal emphasis on these various functions and their representatives may seem to present conflicting evidence. A concern harvesting a natural product may not need to conduct engineering development as extensively as does the manufacturer of highly specialized products. An engineering consultant dealing with technical and economic analyses may specialize in only one or two of these major functions in solving the problems of his clients.

The concept of these few major functions of industry should enable the young engineer to set up his own check list and to compare systematically the opportunities offered by various companies. It should also dispel some of the mystery which arises from differences in terminology between companies. Call the activities what you will, a producer must still devise his product or process, operate the process, and sell his output at a profit if he is to survive.

Qualifications Sought by Industry

Before comparing one detailed field with another, the student might consider the basic personal requirements common to many fields of activity. After all, each of the founder engineering societies draws its members from many fields of employment and from many specific occupations; yet there is enough of common interest and qualifications to maintain and enlarge the membership. Most employers would agree that the primary personal qualifications for any professional position are character, ability and personality; beyond these, they may diverge in their emphasis on detailed skills or experience factors. Initiative and persistence are, of course, implied.

Among engineering students the writer sometimes meets the concept that design engineering is technical detail work—essentially drafting; and that sales engineering activity is principally contact work, with little emphasis on logical analysis or technical understanding. Let us examine these two fields, as encountered in a large manufacturing concern, and determine their common points and their differences.

An engineer engaged in product development and design needs a well-integrated knowledge of basic technical fields. Sound analysis must pave the way for creative engineering. But a career in the field of design also demands further

attributes of the engineer. He may soon have engineering responsibility for an annual output valued at several hundred thousand dollars. Even short of the supervisory level, he may control the direct spending of many thousand of dollars annually, through his use of the services of laboratory personnel, patent attorneys, and appearance designers as well as draftsmen, model builders, testers. He will have contact with other plants and with vendors from other concerns, in addition to dealing with the commercial, manufacturing and field service groups in his own plant. Much of his accomplishment will be by joint effort with others, and not as a lone worker. Evidently the growth of this man's technical and creative ability must be matched by his economic and business sense, if he is to conduct his projects wisely. Also, he must develop skill in human relations, since much of his effectiveness will be determined by the cooperation he can enlist among his associates.

Now consider this man's counterpart in the marketing organization. Marketing technique today is shifting rapidly from inspired guesses to the realistic determination of sales potentials, analysis of users' requirements to guide product development, and a clear understanding of the problems of engineering and of manufacturing. Men headed for marketing activities often are trained first in product development engineering and in the application and installation of products. Here again is the requirement of sound technical ability. Many of today's best sales engineers owe much of their success to the ability to analyze engineering problems without calling on the home office. Our trainee in marketing will advance only if he becomes competent also in his personal relationships, the recognized forte of the salesman. Further, since commercial and industrial purchases are usually investments toward making a profit, he will need sound business judgment to see how the use of his products will benefit his customers.

So, either as development engineer or as sales engineer, our candidate must be well grounded technically, must develop an economic and business perspective, and must learn to work effectively through many personal contacts. This comparison can be extended to include the potential supervisor of manufacturing. The differences are mainly in relative emphasis and personal interests, and only secondarily in basic qualifications. The young engineer of good character, mental ability and personality can get a start without trying to pre-select his exact niche in industry.

As counsellors of engineering students, can we not save effort and extend our effectiveness if we direct their attention then to these few principal classifications of industrial activity and to the balanced qualifications which our students should seek to attain? If by avoiding the details we can pass on to them these broad ideas, they should be able better to classify and integrate the impressions of industry gained through their studies, inspection trips, lectures by industrial visitors and employment interviews.

Considerations such as locality, family background, brief working experience, and the housing situation play a large part in the graduate's choice of post-college employment. These factors, however important, should not influence the choice too heavily since they tend towards decisions reached without adequate knowledge and experience. Our contribution to the young engineer's choice can be a broad and therefore simple perspective of the major functional fields which industry offers, and of the mental and personal qualifications which industrial employers seek for long-term development.

Acoustics in the Electrical Engineering Curriculum

By GEORGE W. SWENSON, JR.
Instructor in Electrical Engineering, University of Wisconsin

In a good many engineering colleges an elective course in acoustics is available to undergraduate electrical engineering students, but in very few is such a course required, even of communications majors. In an elective course in acoustics, registration is apt to be light because of competition from other specialized courses in communications and electronics whose practical applications are more apparent to the student. A large proportion of students, therefore, miss out on what could be a most useful and interesting educational experience.

Acoustics is an old science, and one whose theoretical basis has changed remarkably little since the latter part of the last century, when the analytical methods still in use were perfected. Far from proving that the field has since been static, this fact indicates rather that the mathematical methods advocated by Lord Rayleigh and his contemporaries and predecessors were physically sound and of fundamental importance. Furthermore, a great many other branches of science have profited by the results of early acoustical workers; for example, the detailed theory of electromagnetic wave propagation in hollow conducting tubes was developed by Lord Rayleigh in 1897, using methods previously developed for acoustical analysis.

Every branch of technology which involves wave-motion has mathematical methods in common with acoustics. In acoustics, however, the physical situation is usually easier for the student to appreciate than in most other fields. For example, the vibrating string with fixed end supports is analogous mathematically to a cylindrical electromagnetic resonator operating in a simple mode, but in the case of the string the boundary conditions are more easily visualized than in the case of the resonator. Furthermore, in the laboratory the student can actually *see* nodal points and standing waves on the string. Other analogies of this kind are too numerous to mention. A course in acoustics, therefore, taken as early as possible in the student's career, would enable him to master a number of important analytical techniques with a maximum of understanding of the various physical problems and a minimum of difficulty in formulating them into mathematical terms. His subsequent work in ultra-high-frequency techniques and in any other studies involving partial differential equations would thus be expedited, in that primary attention could then be directed to the physical considerations involved rather than to new mathematical techniques.

A well-balanced course in acoustics should include treatments of lumped-parameter mechanical and acoustical systems. Here the student can learn to appreciate the power and generality of the techniques he learned in his courses in circuit theory. The study of electro-mechanical and electro-acoustical analogies should be introduced in connection with both lumped and distributed-parameter systems, not only to provide a useful analytical method, but also to help the student understand the mathematical unity of various phases of physical science.

A number of classical experiments involving vibrating strings, membranes, and

lumped masses, as well as acoustical tubes and lumped acoustical networks, can readily be adapted for lecture-room demonstrations. None requires elaborate apparatus, and each has the great advantage that the results can readily be observed without the use of complicated measuring equipment which might otherwise divert attention from or obscure the basic phenomena being demonstrated.

If the acoustics course is scheduled soon after the conventional course in differential equations or engineering mathematics, the student's appreciation of the utility of his newly acquired analytical tools will be greatly enhanced.

ANNUAL MEETING

MICHIGAN STATE COLLEGE

June 25-29, 1951

EAST LANSING, MICHIGAN

Teaching Teachers

By LEONARD S. LAWS

Assistant Professor of Mathematics and Mechanics, University of Minnesota

Engineering instructors are concerned about the quality of their teaching and are eager to learn better methods if they are given the opportunity to do so. This fact was demonstrated forcibly last May when the North Midwest Section sponsored a three day Short Course for Engineering Teachers on the campus of the University of Minnesota.

One hundred sixty-five teachers made special arrangements concerning their teaching duties so that they might attend this short course. Since the course was primarily intended to help train the less experienced teachers, many senior staff members assumed the additional teaching load to permit their younger colleagues to attend. This generous gesture was typical of the cooperation the committee received from all members of the North Midwest Section in planning and presenting its teacher-training program.

Features which distinguished this short course from the usual training schools sponsored by the Society were:

1. It was regional and thus was more attractive to the teachers in the lower income brackets.
2. It was held during the academic year—the time when teachers are most concerned with instructional problems.
3. It was aimed at all engineering teachers rather than instructors in a special subject matter field. This allowed for better perspective and for the crossbreeding of ideas between teachers in the various engineering departments.

In determining its program, the committee felt that the less experienced staff members needed an overview of teaching and so it chose the five general topics:

1. Determining teaching objectives.
2. How people learn.
3. The effective use of various teaching methods.
4. The effective use of audio-visual materials.
5. Effective evaluation practices.

One-half day was given to each topic. Each topic was first presented to the entire group in general session by an authority on that subject and then various techniques were used to allow for the exchange of ideas and experiences on the part of the participating members.

After the speakers' presentations of topics 1, 3, and 5 and their replies to questions asked from the floor, the group was sub-divided into small departmental discussion groups. Each group met in a separate room with its own discussion leader. These leaders were representatives from member schools of the North Midwest Section who were best qualified to lead such discussion groups in their own subject matter fields.

Since psychology of learning was of interest to all engineering instructors regardless of subject matter taught, the group stayed in general session following the presentation of topic number two. The resource speaker was discussion leader during that period. Not only did this permit discussion across departmental lines but permitted further questioning of the resource speaker by individuals with special problems. Many participants considered this particular presentation and discussion as the most pregnant topic in the program and indicated a desire to study it further.

After the presentation of the topic

"The effective use of audio-visual materials" by the resource speaker, the Audio-Visual Education Service of the University of Minnesota exhibited selected materials in most of the engineering fields. These materials were listed in a timetable for the convenience of the participants. Each could arrange his own schedule for the remainder of that day. This gave each participant the opportunity of seeing what was available in his own field or, if he so desired, he might cross departmental lines and learn something about a different engineering subject. The choice was left to him.

The response to the short course leaves little doubt in the minds of the committee members that a similar type program would be appreciated by the instructional personnel in many other sections of the A.S.E.E. Many who attended this course have requested that it be continued as an annual event under the sponsorship of the North Midwest Section. A recommendation to that effect is being made by the committee.

A program of this type is only justifiable if it actually inspires some of the participating members to attempt an improvement in their teaching and if it gives them some means for evaluating their efforts. The participants were given the opportunity to evaluate the short course in an opinionnaire which was mailed to them after the meeting had been held. In response to the question "What important plan, decision, or course of action are you considering as a partial result of taking this course?", some replied as follows:

> "In my thermodynamics course—give more practical applications as interest arousers, build tests with a purpose behind them."
>
> "I intend to reduce the amount of time I spend in lecture and to make more use of demonstrations and recitations."
>
> "I intend to read some of the suggested books and am trying to apply some of the suggestions regarding examinations."
>
> "Entertaining plans for giving students more responsibility in conduct of courses."
>
> "Self appraisal, attempt at improving both teaching and testing techniques."
>
> "Beginning next fall, am planning to completely revamp my methods of presentation and evaluation."
>
> "Develop in my own mind a more coherent philosophy of teaching what—and above all why?!"

The committee feels that the program was eminently worth-while. The enthusiastic response on the part of the less experienced teachers indicates that it is only the first step in a more extensive and intensive training program for engineering teachers of the North Midwest Section of A.S.E.E.

Leaders are Made—Engineering Style

By H. A. ESTRIN

Assistant Professor of English, Newark College of Engineering

How does a treasurer set up his books? What are the techniques of writing accurate minutes of the meeting? How can one conduct a meeting according to parliamentary procedure? How can committees operate efficiently? How can an organization establish good public relations with the student body, the faculty, the community?

Students at Newark (New Jersey) College of Engineering have asked these questions periodically. Because of the crying need for help in these matters the Nu Chi Epsilon Fraternity, the honor leadership organization, undertook the responsibility to sponsor a leadership conference for the students, the faculty, and the administration.

In a letter to everyone in the college the conference aims were told:

Yearly, students are elected to responsible positions in their classes, sections, clubs, fraternities, and societies; yet they have little or no knowledge of how to administer their office successfully. Treasurers' reports which amount to hundreds of dollars are haphazardly kept; secretaries' minutes are poorly and inaccurately written; meetings are conducted without parliamentary rules; committees fail to function properly and to fulfill their objectives.

Throughout the college year various kinds of affairs involving the expenditure of large funds and many man hours completely fail, resulting in substantial financial losses and a lowering of the morale of the students involved in the extracurricular activities of the college.

The purposes of this meeting are as follows: to discuss the principles of parliamentary procedures; to suggest a standardization of treasurers' reports and secretarial minutes; to crystallize the concept of the role of the leader; to learn to use public relations effectively; to present resources regarding extracurricular activities; to present the various problems of individual group relations; to try to find solutions to these problems; to promote an *esprit de corps* between leaders of various clubs, teams, classes, and groups; to stimulate more student cooperation and activity within groups.

The conference was conducted in two parts: the panel discussion and the workshops. The panel consisted of four speakers: The President Emeritus of the College spoke on "The Role of the Leader"; the President of the College, "The Use of Committees"; the Director of Public Relations, "The Value of Public Relations"; and the Secretary to the College Faculty, "Techniques of Writing Secretarial Minutes." Each speaker had a student associate. After these speeches the panel was thrown open to enable members of the audience to learn answers from authorities.

After a fifteen-minute intermission which allowed for a general socialization of the panel and the audience, the workshops were formed, based on the individual need of the participant. For example, in the treasurers' workshop the comptroller of the College presented a typical treasurer's form adaptable for all organizations to keep their financial records; pamphlets on "Parliamentary Law" were distributed and discussed in the workshop for parliamentarians and vice-presidents; a procedure for collating resources and texts for all clubs and societies to examine before sponsoring an event was decided upon in the workshop on resources; the dissemination of pub-

licity and the value of public relations were also crystallized in this meeting. Each workshop had a student and a faculty chairman so that an impartial, democratic attitude permeated the meeting.

In each workshop one of the senior members of the honor society recorded the findings and the recommendations of each assemblage. These were mimeographed and distributed to all those who requested them. In this way one can obtain a complete summary of the entire conference.

Some of the pertinent findings that were recorded are as follows:

Workshop for Presidents

The desirable qualifications of a good president are poise and control of temper; respect for time, its value and use; ability to take and give constructive criticism; broadmindedness; wisdom to seek aid from competent sources; and good judgment, or the ability to make good "snap decisions," as well as those based on logical reasoning. All these qualifications are never found in one man, but when a group is electing a president, the man with the most abilities should be chosen.

The success of a president can be measured by determining whether the organization is able to run well for reasonable periods of time without the top man or whether a change in its personnel does not result in noticeable strain or stress.

Workshop for the Parliamentarians and Vice-President

The basic aim of parliamentary procedure is to get the cooperation of the governed. All organizations specify in their by-laws which "rules of order" are to be used by the organization. The candidates for office are usually discussed in caucus before the time for nominations to eliminate abnormal refusals. The mere placing of the names on the ballots is worthless, unless the persons actually desire the job and are properly qualified. It is a good idea to have motions submitted in writing, whenever possible, so as to facilitate the work of the chairman. Parliamentarians should become thoroughly familiar with Roberts' "Rules of Order."

Workshop for Secretaries

Secretaries are not *per se* leaders, though the job may be a stepping stone. Usually the secretary takes little part in discussion because of his transcribing commitments. His minutes are a reflection of the Chair's conduct of a meeting. The importance of his functions depends on the size of the organization, the scope of the activities and the democracy of the meeting. As an aid to accurate and well-planned minutes, whenever possible, the agenda and proposed motions should be obtained in written form before the meeting. The minutes should be read with spirit and in a manner which will assure the members' attention and should become a permanent record of the history and proceedings of the groups.

Workshop for Treasurers

An efficient treasurer will set a specified time for collecting dues and completing records. He should always issue a receipt for money paid in, no matter how much. If possible, he should try to have a checking account. If the organization is large enough, the treasurers should be bonded. Minimum bonding premium is $10.00 per year for small organizations.

This conference had the following results:

1. It brought the administration, the faculty, and the students on a democratic basis to discuss their mutual problems of the College.
2. It gave the students first-hand, tangible information on leadership by assembling the outstanding and proved leaders of the student body, the faculty, and the administration.
3. It specifically offered specialized assistance from experts in the field; that is, the President Emeritus, the

President, the Dean, the Public Relations Officer, the Secretary to the Faculty, and the Comptroller gave concrete facts, techniques, and procedures that will be practical for student organizations.

4. It helped establish an *esprit de corps* among the students, the faculty, and the administration.
5. It afforded the participants an opportunity to acquire new resources and to use the library profitably for the improvement of their organizations.
6. It disseminated valuable and helpful literature.
7. It illustrated the importance of the use of public relations.
8. It awakened a new spirit and interest in extracurricular activities.

TIMELY TIPS

TIMELY TIPS is a new section in the Journal devoted to unique ways of teaching difficult concepts so that they can be easily grasped by students. Contributions to this section should constitute an improvement over current textbook presentations. They should not exceed two Journal pages in length (including illustrations). If you have novel, short-cut methods of making difficult concepts seem simple, your colleagues will be glad to see them in the Journal. Send contributions of the Editor, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

Using the Ordinary Slide Rule to Reciprocate Complex Numbers

By WILLIAM A. EDSON

Professor of Electrical Engineering, Georgia Institute of Technology

Abstract: A simple and rapid means for finding the reciprocal of a complex number is described. The necessary scales, A, C, D, and CI, are found on almost all slide rules. In many electrical network calculations the method is preferable to that employed with the so called "vector" rule.

About fifteen years ago the author devised a convenient method for obtaining the reciprocal of a given complex number by means of a slide rule having only the scales A, C, D, and CI. Because the method does not appear to be well known it is described here.

The problem is to find

$$Y = 1/Z \qquad (1)$$

where Z is given by the equation

$$Z = R + jX \qquad (2)$$

and Y has components

$$Y = G + jB \qquad (3)$$

That is, given the real numbers R and X, to find the corresponding real numbers G and B. Conversely, given G and B one finds R and X by the same procedure.

The first step in the process is reasonably well known* and represents the algebraic manipulation.

$$|Z| = \sqrt{R^2 + X^2} = R\sqrt{1 + (X/R)^2} = X\sqrt{1 + (R/X)^2} \qquad (4)$$

The larger of the two given components is divided by the smaller, and the ratio is found on scale D at the index of C. The square of this ratio is found on the A scale at the same position. The operator momentarily notes this squared ratio, increases it by one, and moves the index of C to correspond. The use of the hairline facilitates this operation because the scales rarely permit the settings by eye and because the hairline can be set to the new position before the original setting of the slide is disturbed. The index of C now corresponds to the magnitude of the radical, and $|Z|$ is found on D opposite the original divisor.

If for example $R = 4$ and $X = 3$ one divides 4 by 3 and finds 1.333 on D. The square of this number, 1.778, is found adjacent on A. When augmented by one this becomes 2.778, whose square root, 1.667, is found adjacent on D. This number, when multiplied by the original divisor, 3, yields $|Z| = 5$ as it should.

The next step, which appears to be novel, and may also be employed with vector rules, depends upon the propor-

* This was pointed out to the author by Professor R. P. Siskind of Purdue University, then at Harvard.

tionality which exists among the components

$$|Z|/|Y| = R/G = -X/B \quad (5)$$

That this is true is readily seen from the similar triangles of Fig. 1. It is applied to the slide rule by bringing $|Z|$ on the CI scale into line with $|Z|$ on the D scale, as found above. This, of course, is equivalent to establishing the ratio expressed by (5) because $|Y|$ on C is adjacent to $|Z|$ on CI. The desired answers G and B are then read off scale C at points opposite R and X on D, without further motion of the slide.

Completing the numerical example, the red 5 on CI is set opposite the black 5 on D, corresponding to $|Z|$. This, of course, is equivalent to setting 0.2 on C opposite 5 on D, but is much easier in execution. The required answers, $G = 0.160$ and $B = -0.120$, are found on C opposite 4 and 3 respectively on D.

As a second example let us find the impedance which is the reciprocal of an admittance $Y = 1 + j2$. The ratio B/G is immediately known and its square on A is 4. Addition of one yields 5 on A corresponding to the absolute magnitude $|Y| = 2.236$ on D. Bringing 2.236 on CI to this position yields $|Z| = 0.447$, $R = 0.200$ and $X = -0.400$.

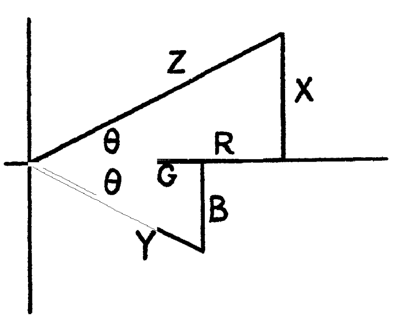


FIG. 1. Similar triangles of impedance and admittance.

It will be found that the examples chosen work well on the stated scales, but that other combinations are greatly facilitated by the use of the folded scales DF, CF, and CIF, which are found on most modern rules.

The method does not give nor require the phase angle, which is sometimes an advantage and sometimes a disadvantage. However, the required reciprocal, in complex (rectangular) form, is obtained without writing down or remembering intermediate results, a real convenience in tabular calculations. Moreover, all of the six important numbers are simultaneously displayed at the final setting, an advantage not shared by conventional vector rules.

In closing it is of interest to note that about ten years ago the K & E Company made up several special slide rules for the Bell Telephone Laboratories. These included a special reciprocation scale designated R which operated on at least substantially the same principles. The operation corresponding to (4) was achieved by transferring the ratio found by division from D to R. These rules were well received by those who had access to them, but have not been produced commercially.

New Members

ACOCK, GEORGE W., Chief Engineer, John A. Roebling's Sons Company, Morrisville, Pa. C. E. Tucker, K. L. Wildes.

ADKINS, HOWARD E., Instructor in Mechanical Engineering, University of Wisconsin, Madison, Wis. B. G. Elliott, C. A. Gilpin.

ASHE, BOWMAN F., President, University of Miami, Coral Gables, Florida, T. C. Brownell, J. H. Clouse.

BEST, CHARLES L., Instructor in Mechanics, Lafayette College, Easton, Pa. L. J. Conover, W. G. McLean.

BOGGS, RAY C., Assistant Professor in Engineering, Evansville College, Evansville, Ind. J. F. Sears, W. O. Hartsaw.

BOWE, LUCIEN P., Instructor in Mathematics, Newark College of Engineering, Newark, N. J. C. Konove, H. Barkan.

BOYLE, THOMAS A., JR., Instructor in Mechanics, University of Michigan, Ann Arbor, Mich. G. V. Edmonson, F. L. Schwartz.

BRITTON, CHARLES C., Assistant Professor in Electrical Engineering, Colorado A. & M. College, Fort Collins, Colo. C. H. Chinburg, H. H. Schweizer.

BURNET, GEORGE, JR., Instructor in Chemical Engineering, Iowa State College, Ames, Iowa. F. Kerekes, S. J. Chamberlin.

BYARS, EDWARD F., Instructor in Mechanics and Hydraulics, Clemson Agricultural College, Clemson, S. C., J. H. Sams.

CALKIN, JOHN B., Director of Department of Industrial Cooperation and Associate Professor of Chemical Engineering, University of Maine, Orono, Me. W. S. Evans, L. C. Jenness.

CAYWOOD, WILLIAM P., JR., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. D. F. Miner, E. R. Schatz.

CHILDERS, GEORGE H., Assistant in Research, University of Florida, Gainesville, Fla. F. M. Flanigan, R. A. Morgen.

CLAUSER, MILTON U., Head of School of Aeronautics, Purdue University, Lafayette, Ind.

CODE, WILLIAM E., Associate Professor of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo. T. H. Evans, H. H. Schweizer.

COPE, JOSEPH H., Associate Professor of Mechanical Engineering, South Dakota School of Mines and Technology, Rapid City, S. D. J. A. Meeker, E. E. Clark.

CURTIS, KENNETH S., Instructor in Surveying and Civil Engineering, Purdue University, Lafayette, Ind. G. E. Lommel, G. P. Springer.

DANFORTH, GEORGE E., Assistant Professor in Architecture, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, L. E. Grinter.

DUCK, FRANCES I., Librarian, Stevens Institute of Technology, Hoboken, N. J. R. O. Vuilleumier, K. J. Moser.

DUNN, ORVILLE E., Instructor in Electrical Engineering, University of Dayton, Dayton, Ohio. L. H. Rose, K. C. Schrout.

EDWARDS, DAVID N., Instructor in Industrial Engineering, Columbia University, New York City, N. Y. D. B. Miller, A. T. Schwab.

FLETCHER, ROBERT H., Assistant Professor of Mechanical Engineering, Texas A. & M. College, College Station, Texas. J. G. H. Thompson, C. W. Crawford.

FRANCIS, LYMAN L., Instructor in Mechanical Engineering, University of Missouri, Columbia, Mo. P. Ogden, O. A. Pringle.

FRAYNE, JOHN G., Manager in Engineering, Westrex Corporation, Hollywood, Calif. C. M. Duke, J. C. Dillon.

GIBBONS, LESLIE L., Assistant Professor in Industrial Arts, Colorado A. & M. College, Fort Collins, Colorado. G. F. Henry, H. H. Schweizer.

GRAHAM, LOIS, Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, F. D. Carvin.

GRAHAM, JAMES D., Assistant Instructor in Electrical Engineering, University of Missouri, Columbia, Mo. J. C. Hogan, G. V. Lago.

GREEN, CECIL H., Vice President, Geophysical Service Inc., Dallas 9, Texas. C. E. Tucker, H. L. Hazen.

HAINLIN, ALBERT W., Assistant Professor of Mechanical Engineering, University of Miami, Coral Gables, Fla. E. Anderson, T. C. Brownell.

HALL, DONALD E., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. P. Ogden, K. Farquharson.

HARVEY, DOUGLAS J., Instructor in Mechanical Engineering, Michigan State College, East Lansing, Mich. D. A. Bergh, H. L. Womochel.

HEINZE, ROBERT C., Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. E. W. Mellon, G. V. Lago.

HOLLNAGEL, HERBERT P., Head of Physics Department, Franklin Technical Institute, Boston, Mass. B. K. Thorogood, P. H. Humphries.

JOERGER, JEROME C., Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. R. A. Imm, B. Wasserman.

KAY, WESLEY K., Instructor in Electrical Engineering, University of Maine, Orono, Me. S. J. Mayo, P. M. Seal.

KEE, WALTER A., Engineering Librarian, New York University, New York 53, N. Y. H. Torgersen, M. C. Giannini.

KELSEY, ELIZABETH L., Instructor in Engineering, John B. Stetson University, DeLand, Fla. A. Bronwell.

KIMBRELL, JACK T., Assistant Professor in Mechanical Engineering, University of Missouri, Columbia, Mo. P. Ogden, N. Bolstad.

KING, WALTER B., JR., Assistant Professor In Mechanical Engineering, University of Miami, Coral Gables, Fla. H. H. Sheldon, J. M. Eubanks.

KRULL, ALAN R., Engineering Librarian, The Cooper Union For the Advancement of Science and Art, New York 3, N. Y. H. C. Whitford, W. B. Embler.

KUBLER, CLARENCE J., Instructor in Civil Engineering, South Dakota School of Mines and Technology, Rapid City, S. D. E. D. Dake, E. E. Clark.

LACKEY, JAMES M., District Engineering, The Asphalt Institute, Glendale, Calif. C. M. Duke, J. C. Dillon.

LANIER, ROSS E., Instructor in Electrical Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, W. B. Stelzner.

LANSING, NEAL F., Physicist—Reactor Technology, Faculty Member of Oak Ridge School of Reactor Technology, Oak Ridge National Laboratory, Oak Ridge, Tenn. P. C. Zmola, R. Stephenson.

LEVINE, MARK P., Instructor in Electrical Engineering, University of Massachusetts, Amherst, Mass. R. R. Brown, G. A. Marston.

LIEBERSOHN, ARON, Electrical Engineer, 252 Hewes St., Brooklyn 11, N. Y. R. S. Marcus, J. R. Elyachar.

LOYE, DONALD P., Lecturer in Engineering and Consulting Engineer, University of California, Los Angeles, Calif. C. M. Duke, J. C. Dillon.

LYMAN, JOHN H., Lecturer in Engineering, University of California, Los Angeles, Calif. M. L. Orr, C. M. Duke.

MACKINTOSH, CHARLES, Instructor in Engineering, University of California, Los Angeles, Calif. C. M. Duke, J. C. Dillon.

MCBRIDE, C. D., Assistant Professor of Industrial, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

MCDOWELL, EDWARD L., Instructor in Mechanics, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, L. E. Grinter.

MERCANTI, ENRICO P., Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. S. E. Rusinoff, J. D. Carvin.

MONAHAN, RAYMOND E., Instructor in Engineering Drawing, University of Minnesota, Minneapolis, Minn. O. W. Potter, A. G. Mudgett.

MUSTER, DOUGLAS F., Instructor in Mechanics, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, L. E. Grinter.

PAQUETTE, RADNOR J., Assistant Professor of General Engineering, University of

Florida, Gainesville, Fla. F. M. Flanigan, C. E. Cutts.

PARKER, MILTON E., Professor and Director of Food Engineering, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, L. E. Grinter.

PENROD, ESTEL B., Head of Mechanical Engineering, University of Kentucky, Lexington, Ky. D. V. Terrell. H. A. Romanowitz.

PRAGER, PHILIP C., Instructor in Mechanical Engineering, Swarthmore College, Swarthmore, Pa. S. T. Carpenter, B. Morrill.

PRICE, THORNTON W., Graduate Student in Mechanical Engineering, University of Illinois, Urbana, Ill. R. B. Delloway, N. A. Parker.

RESNICK, SOL D., Assistant Professor of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo. D. F. Peterson, H. H. Schweizer.

ROSSINI, FREDERICK D., Professor and Head of Chemistry, Carnegie Institute of Technology, Pittsburgh, Pa. J. W. Graham, Jr., D. F. Miner.

RUBINSKY, STANLEY, Assistant Professor of Mechanical Engineering, Mississippi State College, State College, Miss. H. P. Neal, A. G. Holmes, Jr.

RUSH, N. ORWIN, Director of Library, University of Wyoming, Laramie, Wyo. H. T. Person, H. Fry.

SAGADY, ALEXANDER J., Instructor in Engineering Drawing, Detroit Institute of Technology, Detroit, Mich. L. L. Henry, E. A. Lucitte.

SANFORD, JOHN R., Instructor in Electrical Engineering, University of Toledo, Toledo, Ohio. W. F. Brown, W. S. Smith.

SCHOTT, FREDERICK W., Assistant Professor, University of California, Los Angeles, Calif. G. J. Tauxe, C. M. Duke.

SEABOCH, JAMES R., Instructor in Industrial, University of Arkansas, Fayetteville, Ark. G. F. Branigan, H. W. Risteen.

SHIMIZU, KINJI, President, Nagoya Institute of Technology, Nagoya, Japan. O. W. Eshbach, A. B. Bronwell.

SIMPSON, CHARLES E., Administrative Assistant, University of California, Los Angeles, Calif. W. L. Orr, C. M. Duke.

SMATKO, JOSEPH S., Associate Professor of Chemical Engineering, University of Maryland. R. B. Allen, L. E. Otto.

STANSBURY, E. E., Associate Professor in Chemical Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, R. M. Boarts.

STATER, GORDON, Attorney at Law, University of California, Los Angeles, Calif. C. M. Duke, J. C. Dillon.

STEVENS, HELEN L., Assistant Professor of English, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, W. W. Colvert.

STEWART, ROBERT E., Instructor in Agricultural Engineering, University of Missouri, Columbia, Mo. M. M. Jones, G. V. Lago.

STIGERS, MARQUIS F., Director of Cooperative Engineering, Evansville College, Evansville, Ind. J. F. Sears, W. O. Hartsaw.

TANGUAY, PHILLIP O., Industrial Coordinator and Placement Director of Student Personnel, University of Bridgeport, Bridgeport, Conn. D. C. Hunt.

THOMASSEN, HENRY S., Associate Editor in Technical Education, McGraw-Hill Book Company, New York, N. Y. E. E. Booher, H. W. Shaw.

TINDAL, ROBERT T., Assistant Professor of Civil Engineering, University of Miami, Coral Gables, Fla. M. I. Mantell, T. C. Brownell.

TINGEY, WILLIS A., Assistant Professor of Civil Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

TORAN, NESTOR E., Project Engineer, Baird Associates, Inc., Boston, Mass. W. E. Keith, L. W. Hitchcock.

TRUMPLER, PAUL R., Professor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, F. D. Carvin.

TURNER, WALTER W., Assistant Professor of Electrical Engineering, University of Maine, Orono, Me. W. J. Creamer, P. M. Seal.

VOLTERRA, ENRICO G., Associate Professor of Mechanics, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, L. E. Grinter.

WALKER, CHARLES R., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, A. T. Granger.

WALKER, ROBERT E., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. R. T. Quck, H. O. Croft.

WALTERS, LOUIS G., Associate in Engineering, University of California, Los Angeles, Calif. G. J. Tauxe, C. M. Duke.

WEAVER, CHARLES H., Assistant Professor of Electrical Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, H. M. Scull.

WEEBER, ROBERT E., Assistant Professor, University of Toledo, Toledo, Ohio. W. F. Brown, W. S. Smith.

WEINERT, GLEN A., Instructor in Mechanical Engineering, Ohio University, Athens, Ohio. E. J. Taylor, P. H. Black.

YANG, TSUTE, Assistant Professor of Electrical Engineering, University of Toledo, Toledo, Ohio. W. F. Brown, W. S. Smith.

YATES, EDWIN L., Director of College and University Relations, General Motors Corporation, Detroit 2, Mich. K. A. Meade, J. C. McElhany.

ZIZICAS, GEORGE A., Junior Engineer, Engineering Research, University of California, Los Angeles, Calif. M. L. Orr, C. M. Duke.

270 new members this year

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 15, 1951 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President ....

....

For Vice-President ....
(In Charge of General and Regional Activities—two years)

....

For Treasurer ....

....

Signed ....

Title ....

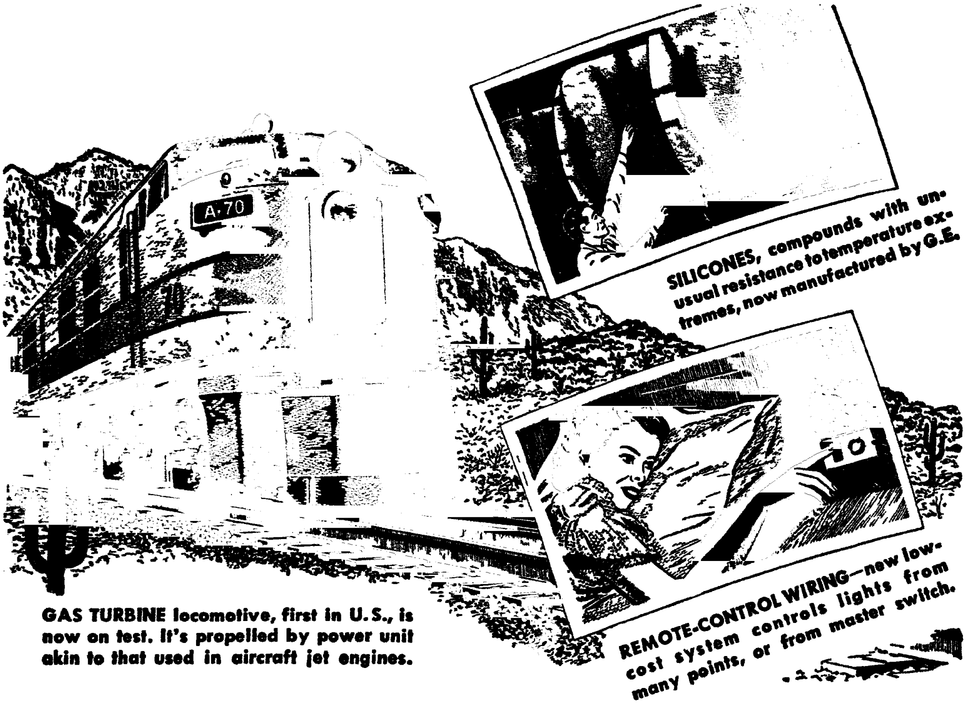
Institution ....

Date ....

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf Northwestern University
Kansas-Nebraska	Kansas State College		Kenneth Rose, University of Kansas
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	C. H. Willis, Princeton University
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University U. S. Naval Post Graduate School	Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University		E. D. Howe, University of California
Rocky Mountain			J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings



GAS TURBINE locomotive, first in U.S., is now on test. It's propelled by power unit akin to that used in aircraft jet engines.

SILICONES, compounds with unusual resistance to temperature extremes, now manufactured by G.E.

REMOTE-CONTROL WIRING—new low-cost system controls lights from many points, or from master switch.

These new G-E developments are creating exciting new opportunities for G-E men

The gas turbine, drawing power from red-hot gases, is being applied by General Electric to the propulsion of locomotives, ships, and planes, and to the generation of electricity. More than 350 G-F engineers, physicists and other specialists, assigned to this work, are in on the ground floor of a development that promises to revolutionize the production of power.

It's a similar story for the specialists working today in the development of G-E silicones, and for those who are helping to win a place for G-E remote-control wiring.

New developments like these are opening up new opportunities at General Electric, giving more college graduates the chance of finding exciting, satisfying work.

By placing prime importance on the development of talent and skill, by providing incentives for creative minds, General Electric keeps ahead in electrical research, engineering, and manufacturing.

You can put your confidence in—

GENERAL ELECTRIC

1950 Enrollment in Engineering Colleges

By ROBERT C. STORY and HENRY H. ARMSBY *

Approximately 161,000 engineering students were enrolled this fall in the 142 [1] schools accredited by the Engineers' Council for Professional Development. The number of under-graduate students was 142,954; the number studying for the master's degree was 15,575; the number studying for the doctor's degree was 2,795.

The number of undergraduate students enrolled in institutions accredited by ECPD decreased 20.9 per cent from last year. At the graduate level, however, the number of students enrolled for the master's degree increased 3.3 per cent over the 1949 figure, while the number of students working for the doctor's degree was 10 per cent above 1949.

As compared with an over-all drop of 6.5 per cent in the total number of students registered in all higher educational institutions, the decline in the number of students enrolled in ECPD accredited schools was 18.6 per cent.

By class level, the per cent distribution of undergraduate enrollment was as follows: freshmen, 23.5; sophomores 21.7; juniors, 24.7; and seniors, 30.1. These per cents are approximately the same as for the preceding year. In comparing the number of students reported at each class level in both 1949 and 1950, this year's freshman class was found to be 19.5 per cent smaller than that reported in the previous year. The sophomore, junior and senior classes declined 23.6, 25.8 and 26.1 per cent, respectively, from the preceding year.

Two major factors contributed to the disproportionate decline in the number of engineering students this fall. On the one hand, the engineering schools, with predominately male student bodies, suffered greater losses through graduation in 1949–50 than did the colleges as a whole. On the other hand, proportionately fewer freshmen enrolled in engineering colleges than in all higher institutions. In engineering schools this fall, freshmen comprised 18.2 per cent of all students as compared to an over-all 23 per cent. The consistently diminishing numbers of new students each year since the fall of 1946 portends a concommitant decline in the number of engineering graduates in the years immediately ahead.

Another disturbing element in the engineering enrollment picture is the decline in the proportion of engineering students. Last fall, the students enrolled in ECPD accrediated institutions comprised 8 per cent of all college students. This year the engineering students accounted for only 7 per cent of the total college enrollment. One fact, clearly apparent from a comparison of engineering enrollment with all college enrollment, is that proportionately fewer students are choosing engineering as a career.

The 142 institutions accredited by the ECPD conferred, during the year ending June 30, 1950, a total of 48,160 bachelor's degrees in engineering, 4,865 master's and professional degrees, and 492 doctorates. These constitute 11.1 per cent of all bachelor's degrees conferred by U. S. colleges and universities, 8.4 per

* Of the U. S. Office of Education, Federal Security Agency. Mr. Story is Head, Technical Services Unit, Research and Statistical Service, and Mr. Armsby is Associate Chief for Engineering Education, Division of Higher Education.

[1] Eighteenth Annual Report (September 30, 1950) of the Engineers' Council for Professional Development.

cent of all master's degrees and 7.4 per cent of all doctorates. Last year these per cents were 11.4, 9.4, and 7.9, respectively.

The distribution of first degrees among the four principal engineering curricula was as follows: Mechanical engineering, 13,056; electrical engineering, 12,340; civil, 7,312, and chemical, 4,422.

In terms of the per cent of change from the previous year, almost 20 per cent more students were graduated in civil and electrical engineering. The number graduating in mechanical engineering was 12.4 per cent greater while the number of graduates in chemical engineering increased 6.9 per cent.

The data contained in this report are based on a survey of engineering schools and colleges made in October 1950, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by the joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education [2] which reported that they conferred degrees in engineering during 1949–50 [3] were requested to supply data. Eight Canadian institutions were also included. Replies were re-

[2] Education Directory, Part III, Higher Education, 1949–50.

[3] Earned Degrees Conferred in Higher Educational Institutions, 1949-50, Circular 282a, U. S. Office of Education, November 1950.

ENGINEERING STUDENTS ENROLLED IN U. S. AND CANADIAN INSTITUTIONS, AND DEGREES CONFERRED

Item	Number of Schools	Number Enrolled, Fall 1950			Degrees Conferred, 1949–50
		Men	Women	Total	
(1)	(2)	(3)	(4)	(5)	(6)
Enrolled in ECPD accredited schools:					
Undergraduate (bachelor's)	142	142,391	563	142,954	48,160
Graduate (master's)	115	15,516	59	15,575	4,865
(doctor's)		2,790	5	2,795	492
Enrolled in other U. S. schools:					
Undergraduate (bachelor's)	48	18,583	55	18,638	4,572
Graduate (master's)	8	293	1	294	39
(doctor's)		6	0	6	2
Enrolled in all U. S. schools:					
Undergraduate (bachelor's)	190	160,974	618	161,592	52,732
Graduate (master's)	123	15,809	60	15,869	4,904
(doctor's)		2,796	5	2,801	494
Enrolled in Canadian Schools:					
Undergraduate (bachelor's)	7	4,130	14	4,144	1,709
Graduate (master's)	6	133	0	133	61
(doctor's)		8	0	8	0
Enrolled in U. S. and Canadian schools:					
Undergraduate (bachelor's)	197	165,104	632	165,736	54,441
Graduate (master's)	129	15,942	60	16,002	4,965
(doctor's)		2,804	5	2,809	494

ceived from all institutions accredited by the ECPD, from 48 other U. S. institutions, and from 7 in Canada.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE general council, the tabulations in this report list individually only the ECPD accredited institutions (eligible for active institutional membership in the ASEE) but contain data for the other U. S. institutions as a group and for the Canadian institutions as a group. Detailed data for these two groups will be made available by the U. S. Office of Education.

Definition of Items:

Period covered: Engineering schools were asked to report student enrollment as of October 6, 1950. A few institutions, however, because of late opening, were unable to report before late November. Degree data are for the period July 1, 1949 to June 30, 1950.

Undergraduate students: Institutions were requested to report by class level only those full-time students who were enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) may include degree candidates as well as students who are not working toward a degree.

Graduate students: Institutions were requested to "Report all students who have been admitted to formal graduate standing and are enrolled in graduate courses—regardless of the number of credit hours carried by the student, and regardless of whether the student's work is administered by the engineering college or the graduate school."

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENTS
(for United States only)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Yr.	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	12,945	108,291	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	17,766	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	16,912	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)

Graduate Enrollment

	Master's Degrees and other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)

	1940	1947	1948	1949	1950
Total college enrollment in U. S.	1,490,000	2,333,000	2,410,000	2,456,000	—
Engineering enrollment in U. S.	113,497	244,390	241,554	187,970*	161,324*
Per cent engineering to total.............	7.6%	10.5%	10%	7.7%*	

* Includes only ECPD accredited institutions.

Undergraduate Engineering Enrollment, by Curricula, October 6, 1950

Engineering Curricula	No. of Schools	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1949–50	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-time Day and Evening Students	Special Day and Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	40	942	813	827	981	33	48	222	32	3,873	25	1,264	15
Agricultural	34	319	377	451	569	29	—	3	7	1,755	—	592	—
Architectural	28	802	914	941	1,078	182	47	43	5	3,977	35	821	8
Ceramic	13	127	169	189	268	10	8	—	9	776	4	278	4
Chemical	106	2,686	2,921	3,147	3,695	124	301	620	123	13,559	58	4,402	20
Civil	130	3,886	4,836	5,574	6,480	104	288	980	301	22,407	42	7,302	10
Electrical	133	4,793	5,727	6,742	8,453	167	559	2,098	506	29,001	44	12,329	11
Engineering Mechanics	25	6	8	19	24	—	—	—	—	56	1	14	—
Engineering Physics	31	326	366	430	429	24	11	25	11	1,610	12	453	2
General Engineering	27	621	610	553	803	—	2	545	3	3,131	6	1,210	3
Geological	22	288	300	304	341	1	—	1	4	1,236	3	332	1
Industrial[1]	63	738	1,095	1,631	2,087	84	85	213	58	5,983	8	2,863	5
Mechanical	128	5,020	6,291	7,598	9,514	235	691	2,446	411	32,156	50	13,036	20
Metallurgical	49	478	526	643	767	29	29	244	7	2,710	4	949	1
Mining	31	286	335	401	473	7	1	3	6	1,511	1	462	1
Naval Arch. & Marine	3	36	52	64	91	8	—	—	1	252	—	62	—
Petroleum	23	690	666	796	985	10	—	5	15	3,162	5	947	1
Sanitary	20	36	30	37	77	1	—	—	—	181	—	49	—
Textile	4	103	100	105	109	—	—	—	3	420	—	196	1
Unclassified	82	6,972	803	101	58	2	—	4,690	849	13,217	258	44	1
Others	41	239	303	404	425	21	9	2	13	1,409	7	446	5
Total E.C.P.D.	142	29,394	27,242	30,957	37,707	1,071	2,079	12,140	2,364	142,391	563	48,051	109
Other U.S. Schools	48	4,905	3,673	3,466	3,995	68	296	2,173	62	18,583	55	4,567	5
All U.S. Schools	190	34,299	30,915	34,423	41,702	1,139	2,375	14,313	2,426	160,974	618	52,618	114
Canadian Schools	7	806	763	908	1,153	474	40	—	—	4,130	14	1,708	1
Grand Total (U.S. & Canada)	197	35,105	31,678	35,331	42,855	1,613	2,415	14,313	2,426	165,104	632	54,326	115

[1] Includes administrative engineering, management engineering, etc.

Total Undergraduate Engineering Enrollment, by School, October 6, 1950

Institution	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1949–50	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5 yr. Curriculum	5th yr. of Cooperative Program	Part-Time Day and Evening Students	Special Day and Evening Students	Total Men	Total Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited Schools:												
Ala. Poly	407	328	309	276	—	—	—	13	1,332	1	577	2
Univ. Ala.	150	130	188	197	—	—	384	2	1,049	2	341	—
Alabama												
Univ. of Ariz.	163	177	175	233	—	—	—	5	751	2	197	—
Arizona												
Univ. Arkansas	86	116	137	181	—	—	—	—	519	1	235	—
Arkansas												
Calif. Tech.	174	62	83	82	—	—	—	—	401	—	99	—
Stanford	137	137	148	147	—	—	—	—	569	—	231	—
Univ. Calif. Los A.	120	143	224	161	—	—	—	—	648	—	220	1
Univ. Calif.	211	273	683	789	—	—	—	—	1,950	6	964	7
Univ. So. Calif.	61	102	393	549	—	—	122	54	1,281	—	635	1
Santa Clara	61	60	67	55	9	—	—	—	252	—	74	—
California												
Colo. A & M.	142	107	115	145	—	—	—	—	509	—	171	—
Colo. Mines	224	204	246	229	—	—	—	—	902	1	240	1
Univ. Colo.	267	269	476	485	—	—	462	10	1,956	13	705	5
Univ. Denver	95	79	110	188	—	6	18	—	492	4	269	1
Colorado												
U.S. Coast Guard	203	133	88	66	—	—	—	—	490	—	66	—
Univ. Conn.	249	199	178	188	—	—	—	—	814	—	234	—
Yale	200	207	211	232	—	—	—	—	850	—	361	—
Connecticut												
Univ. Delaware	85	73	101	143	—	—	—	—	400	2	160	—
Delaware												
Univ. Florida	385	310	172	246	—	—	—	—	1,112	1	287	—
Florida												
Georgia Tech.	958	742	827	747	27	—	—	—	3,301	—	1,196	—
Georgia												
Univ. Idaho	117	114	103	131	—	—	—	—	465	—	126	—
Idaho												
Il. Inst. Tech.	249	330	538	740	—	65	3,637	19	5,356	222	816	3
Northwestern	163	164	161	120	—	143	—	30	779	2	199	—
Univ. Illinois	953	778	788	976	1	—	—	—	3,475	21	1,146	2
Illinois												
Notre Dame	435	239	223	131	—	—	—	—	1,028	—	302	—
Purdue	869	950	1,216	1,601	—	—	—	310	4,920	26	2,045	3
Rose Poly	82	71	91	76	—	—	3	—	323	—	188	—
Indiana												

Iowa State Col.	529	414	522	459	—	—	—	—	1,916	8	867	—
State Univ. Iowa	65	100	91	114	—	—	—	—	370	—	228	1
Iowa												
Kansas State Col.	164	206	262	379	—	—	—	—	1,009	2	515	—
Univ. Wichita	150	40	26	13	—	—	51	—	280	—	13	—
Univ. Kansas	127	184	284	411	—	—	—	—	999	7	424	1
Kansas												
Univ. Kentucky	176	201	183	261	—	—	—	4	820	5	402	1
Univ. Louisville	85	91	111	106	43	—	—	—	436	—	105	—
Kentucky												
La. St. Univ.	282	187	280	398	—	—	—	—	1,144	3	469	1
Tulane	132	96	73	107	—	—	4	—	411	1	122	—
La. Poly. Inst.	152	77	108	113	—	—	—	10	459	1	148	—
Louisiana												
Univ. Maine	147	190	310	352	—	—	—	4	1,003	—	349	—
Maine												
Johns Hopkins	136	138	114	126	—	—	9	1	524	—	143	—
Univ. Maryland	267	224	212	262	2	—	—	—	966	1	278	—
Naval Post-Grad. Sch.	—	—	138	141	—	—	—	—	279	—	146	—
Maryland												
Harvard	—	41	29	19	—	—	—	—	89	—	27	—
Mass. Inst. Tech.	572	547	692	837	8	—	—	—	2,646	10	866	2
Northeastern	560	390	392	434	—	340	—	—	2,108	8	257	4
Tufts	170	148	118	135	—	—	—	—	571	—	137	2
Univ. Mass.	97	65	102	130	—	—	—	—	394	—	237	—
Worcester Poly.	172	172	172	165	—	—	—	—	681	—	191	—
Massachusetts												
Mich. M. & T.	270	263	267	334	9	—	5	—	1,147	1	502	—
Mich. State Col.	182	189	334	461	—	—	—	—	1,165	1	559	1
Univ. Detroit	308	268	277	397	—	546	176	—	1,970	2	271	—
Univ. Michigan	330	379	654	969	—	—	—	27	2,347	12	1,122	4
Wayne Univ.	293	272	265	230	—	—	—	95	1,150	5	1,122	1
Michigan												
Univ. of Minn.	359	338	400	707	157	—	—	31	1,989	3	1,134	2
Minnesota												
Miss. State Col.	97	106	117	161	—	—	—	—	481	—	212	—
Univ. Miss.	48	36	46	46	—	—	—	1	177	—	37	—
Mississippi												
Mo. Mines	156	253	440	633	—	—	—	—	1,478	4	818	4
Univ. Missouri	153	156	169	268	—	—	—	—	746	—	343	—
Wash. Univ. St. L.	125	169	214	220	—	—	—	—	725	3	299	2
Missouri												
Montana Mines	60	68	56	72	—	—	—	—	256	—	53	—
Montana St. Col.	95	133	94	187	—	—	—	—	509	—	270	—
Montana												
Univ. Nebraska	172	185	175	274	—	—	—	1	805	2	395	2
Nebraska												
Univ. Nevada	109	55	53	44	—	—	—	12	272	1	158	—
Nevada												
Dartmouth	65	42	26	28	—	—	—	—	161	—	29	—
Univ. New Hampshire	120	109	100	113	—	—	—	7	449	—	156	1
New Hampshire												
Newark	222	307	312	318	—	—	997	—	2,148	8	394	2
Princeton	143	120	127	144	—	—	—	—	534	—	141	—
Rutgers	115	95	115	168	—	—	—	1	492	2	154	—
Stevens	190	239	181	324	—	—	2	1	937	—	340	—
New Jersey												

Total Undergraduate Engineering Enrollment, by School, October 6, 1950—*Continued*

Institution	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1949–50	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time Day and Evening Students	Special Day and Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
New Mex. Mines	77	63	74	92	—	—	1	—	305	2	115	—
Univ. New Mexico	121	127	141	145	—	—	—	47	381	3	215	—
New Mexico												
Alfred	70	50	54	54	—	—	—	8	234	2	74	1
Brooklyn Poly	172	330	422	433	—	—	2,015	—	3,372	—	445	—
Clarkson	212	231	264	324	—	—	4	—	1,035	—	379	—
City Col. of N. Y.	665	471	393	620	—	—	—	1,041	3,166	24	749	9
Columbia	—	—	114	158	—	—	—	—	272	—	232	—
Cooper Union	103	95	67	61	—	—	375	—	697	4	161	3
Cornell	490	416	278	292	180	—	—	8	1,652	12	525	2
Manhattan	184	155	180	308	—	—	—	—	827	—	215	—
N. Y. Univ.	252	313	370	410	—	—	1,344	26	2,710	5	529	—
Pratt	56	57	76	140	—	—	—	—	327	2	193	1
Rensselaer	615	639	795	1,173	—	—	—	216	3,418	20	1,184	3
Syracuse	128	175	216	395	—	—	—	4	914	4	517	4
Union Col.	82	55	50	75	—	—	47	5	314	—	111	—
Rochester	49	29	64	57	—	—	—	—	199	—	101	—
Webb	18	14	10	14	—	—	—	—	56	—	19	—
New York												
Duke	106	88	87	98	—	—	—	—	379	—	115	1
N. C. State Col.	395	378	316	492	—	—	—	—	1,578	3	557	1
North Carolina												
N. D. Ag. Col.	85	73	101	127	—	—	—	—	386	—	—	—
Univ. N. Dakota	53	41	65	97	—	—	—	—	256	—	132	—
North Dakota												
Akron	70	72	40	77	—	—	—	1	258	2	138	1
Case	270	288	345	320	—	—	207	4	1,434	—	551	—
Cincinnati	335	271	299	288	—	324	—	—	1,516	1	290	3
Fenn	91	127	126	160	—	120	552	64	1,234	6	212	4
Ohio State Univ.	417	413	367	443	572	119	101	21	2,447	6	546	5
Toledo	108	87	136	164	—	—	231	—	722	4	253	1
Ohio												
Okla. A. & M.	291	209	267	495	—	—	—	4	1,260	6	554	1
Tulsa	127	145	133	137	—	—	—	19	559	2	115	—
Univ. Okla.	371	348	458	753	—	—	—	—	1,930	—	643	1
Oklahoma												
Oregon State Col.	226	198	211	298	—	—	—	—	932	1	527	1
Oregon												
Bucknell	86	77	88	96	—	—	—	—	345	2	169	—
Carnegie	250	268	281	262	—	—	679	8	1,744	4	408	1
Drexel	335	289	245	238	—	249	260	14	1,627	3	193	2
Lafayette	129	139	145	185	—	—	—	—	598	—	213	—

Lehigh	457	387	326	300	—	—	—	—	1,470	—	440	—
Penn State Col.	757	645	640	655	—	—	—	17	2,709	5	834	1
Pittsburgh	293	343	385	448	—	—	358	—	1,825	2	738	1
Swarthmore	20	25	25	25	—	—	—	4	98	1	53	—
Univ. Pennsylvania	104	92	134	113	—	—	—	1	444	—	175	—
Villanova	121	105	104	144	2	—	—	—	476	—	289	—
Pennsylvania												
Brown	99	53	41	83	—	—	—	—	273	3	145	—
R. I. State Col.	128	111	115	147	—	—	—	—	497	4	184	—
Rhode Island												
Citadel	111	82	69	88	—	—	—	—	350	—	145	—
Clemson	416	224	246	193	—	—	—	—	1,079	—	306	—
Univ. S. Carolina	104	79	78	130	—	—	11	—	401	1	136	—
South Carolina												
S. Dakota Mines	123	71	91	152	—	—	—	—	436	1	169	—
S. Dakota State Col.	71	67	70	93	—	—	—	—	300	1	146	—
South Dakota												
Univ. Tennessee	173	214	218	240	—	66	—	5	916	—	380	—
Vanderbilt	104	110	103	107	—	—	—	—	424	—	192	—
Tennessee												
A. & M. Col. Texas	804	830	678	499	38	—	43	11	2,903	—	863	—
Rice	146	101	76	85	—	—	—	—	406	2	94	—
Southern Methodist	133	90	48	77	—	101	16	9	474	—	207	—
Texas Col. A. & I.	53	63	38	46	—	—	—	—	199	1	60	1
Texas Tech. Col.	224	168	221	335	—	—	—	—	945	3	336	2
Texas Western	132	85	66	52	—	—	—	—	335	—	65	—
Univ. Texas	266	387	490	597	—	—	—	—	1,731	9	687	—
Texas												
Utah Ag. Col.	30	29	48	40	—	—	—	—	147	—	54	—
Univ. Utah	119	194	238	188	—	—	—	—	738	1	231	—
Utah												
Norwich	63	39	48	67	—	—	—	—	217	—	52	—
Univ. Vermont	57	49	53	83	—	—	—	3	245	—	103	—
Vermont												
Va. Military Inst.	153	101	94	107	—	—	—	—	455	—	119	—
Va. Poly. Inst.	469	430	421	649	—	—	3	8	1,980	—	804	—
Univ. Virginia	79	69	102	116	—	—	—	—	365	1	97	—
Virginia												
Wash. State Col.	177	125	180	179	23	—	—	—	682	2	281	—
Univ. Washington	389	231	248	425	—	—	—	—	1,289	4	510	1
Washington												
W. Virginia Univ.	79	145	193	208	—	—	—	8	633	—	314	—
West Virginia												
Marquette	177	235	221	280	—	—	—	137	1,050	—	358	—
Univ. Wisconsin	523	433	482	542	—	—	—	—	1,980	—	790	—
Wisconsin												
Univ. Wyoming	79	81	83	117	—	—	—	—	357	3	212	1
Wyoming												
Catholic Univ.	62	68	126	195	—	—	23	—	474	—	270	—
George Washington Univ.	163	126	147	189	—	—	—	33	652	6	168	—
Howard Univ.	56	33	38	57	—	—	—	—	183	1	47	—
District of Columbia												
Univ. Alaska	—	1	—	1	—	—	—	—	2	—	—	—
Alaska												
Total ECPD Schools	29,394	27,242	30,957	37,707	1,071	2,079	12,140	2,364	142,391	563	48,051	109

Graduate Engineering Enrollment, by Curricula, October 6, 1950

Engineering Curricula	No. of Schools	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1949–50	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Schools accredited by ECPD:																			
Aeronautical	34	452	201	648	5	305	—	37	—	37	—	21	—	110	41	151	—	25	—
Agricultural	22	138	147	285	—	40	—	—	—	—	—	—	—	17	—	17	—	2	—
Architectural	12	69	—	67	2	12	—	—	—	—	—	—	—	2	—	2	—	—	—
Ceramic	14	72	—	72	—	54	—	—	—	—	—	—	—	34	—	34	—	14	—
Chemical	83	1,149	871	2,009	11	698	1	20	3	23	—	12	—	568	106	672	2	178	—
Civil	89	1,032	789	1,815	6	704	1	12	3	15	—	20	—	190	30	220	—	32	—
Electrical	94	1,781	2,475	4,250	6	1,133	1	48	4	52	—	31	—	568	184	751	1	85	—
Engineering Mechanics	26	159	50	209	—	69	—	6	—	6	—	1	—	107	3	110	—	13	—
Engineering Physics	16	90	82	165	7	66	—	—	—	—	—	—	—	29	2	31	—	1	—
General Engineering	4	90	26	116	—	22	1	—	—	—	—	—	—	31	—	30	1	3	—
Geological	11	94	—	94	—	19	1	—	—	—	—	—	—	16	—	16	—	—	—
Industrial[2]	32	332	733	1,063	2	241	2	—	—	—	—	12	—	9	34	43	—	3	—
Mechanical	93	1,371	1,437	2,801	7	809	1	44	1	45	—	14	—	264	24	287	1	48	—
Metallurgical	40	306	247	550	3	179	1	4	—	4	—	4	—	205	26	231	—	46	—
Mining	21	71	10	81	—	32	—	1	—	1	—	4	—	13	—	13	—	1	—
Naval Arch. & Marine	4	20	—	20	—	10	—	92	—	92	—	27	—	1	—	1	—	—	—
Petroleum	13	141	2	143	—	71	—	—	—	—	—	1	—	11	—	11	—	2	—
Sanitary	16	114	—	114	—	71	—	10	—	10	—	1	—	20	—	20	—	2	—
Textile	2	16	—	16	—	6	—	—	—	—	—	—	—	3	—	3	—	1	—
Unclassified	18	65	258	317	6	35	—	—	—	—	—	—	—	1	—	1	—	7	—
Others	24	310	86	392	4	129	1	4	—	4	—	2	—	143	3	146	—	29	—
Total E.C.P.D.	115	7,872	7,414	15,227	59	4,705	10	278	11	289	—	150	—	2,342	453	2,790	5	492	—
Other U.S. Schools	8	127	167	293	1	39	—	—	—	—	—	—	—	6	—	6	—	2	—
All U.S. Schools	123	7,999	7,581	15,520	60	4,744	10	278	11	289	—	150	—	2,348	453	2,796	5	494	—
Canadian Schools	6	125	8	133	—	61	—	—	—	—	—	—	—	7	1	8	—	—	—
Grand Total (U.S. and Canada)	129	8,124	7,589	15,653	60	4,805	10	278	11	289	—	150	—	2,355	454	2,804	5	494	—

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[2] Includes administrative engineering, management engineering, etc.

Total Graduate Engineering Enrollment, by School, October 6, 1950

Institution	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1949–50	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited Schools:																		
Alabama Poly	10	—	9	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Alabama	18	15	33	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Alabama																		
Univ. Arizona	14	—	14	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Arkansas	30	—	30	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—
Arkansas																		
Calif. Tech	97	—	97	—	86	—	36	—	36	—	21	—	65	—	65	—	22	—
Stanford	190	—	190	—	130	—	36	—	36	—	15	—	59	—	59	—	15	—
Univ. Calif. Los A.	87	—	87	—	14	1	—	—	—	—	—	—	30	—	29	1	2	—
Univ. Calif.	231	—	228	3	86	—	17	—	17	—	3	—	75	—	75	—	13	—
Univ. So. Calif.	110	174	284	—	69	—	14	2	16	—	22	—	4	2	6	—	—	—
California																		
Colo. A. & M.	15	—	15	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. Mines	76	—	76	—	18	—	—	—	—	—	—	—	36	—	36	—	1	—
Univ. Colorado	62	172	234	—	57	—	—	—	—	—	5	—	3	—	3	—	—	—
Univ. Denver	17	10	27	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Colorado																		
Univ. Connecticut	16	62	78	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ.	69	3	72	—	49	—	—	—	—	—	—	—	49	—	49	—	17	—
Connecticut																		
Univ. Delaware	12	97	109	—	18	—	—	—	—	—	—	—	1	24	25	—	8	—
Delaware																		
Univ. Florida	75	—	75	—	27	—	—	—	—	—	—	—	13	—	13	—	—	—
Florida																		

Total Graduate Engineering Enrollment, by School, October 6, 1950—*Continued*

Institution	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees Conferred in Eng'g 1949–50		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1949–50	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(17)	(19)
Georgia Tech.	149	—	149	—	89	—	—	—	—	—	—	—	27	—	27	—	1	—
Georgia																		
Univ. Idaho	11	—	11	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Idaho																		
Illinois Inst. Tech.	190	435	623	2	82	—	—	—	—	—	—	—	47	—	46	1	6	—
Northwestern	75	37	112	—	40	—	—	—	—	—	—	—	41	2	43	—	11	—
Univ. Illinois	300	—	300	—	205	—	—	—	—	—	—	—	216	—	216	—	21	—
Illinois																		
Notre Dame	44	—	44	—	21	—	—	—	—	—	—	—	10	—	10	—	1	—
Purdue	286	24	310	—	187	—	—	8	8	—	3	—	139	—	139	—	23	—
Rose Poly	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Indiana																		
Iowa State Col.	96	—	96	—	50	—	—	—	—	—	—	—	55	—	55	—	12	—
State Univ. Iowa	72	—	71	1	48	—	—	—	—	—	—	—	28	—	28	—	10	—
Iowa																		
Kansas State Col.	53	—	53	—	28	—	5	—	5	—	—	—	—	—	—	—	—	—
Univ. Wichita	4	—	4	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Kansas	44	—	44	—	16	—	—	—	—	—	—	—	12	—	12	—	—	—
Kansas																		
Univ. Kentucky	44	—	44	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Louisville	26	—	26	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
La. State Univ.	60	—	60	—	37	—	—	—	—	—	—	—	5	—	5	—	3	—
Tulane Univ.	13	—	13	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana																		
Univ. Maine	24	5	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine																		
Johns Hopkins	101	53	152	2	62	—	—	—	—	—	—	—	58	4	62	—	11	—
Univ. Maryland	248	150	397	1	25	—	—	—	—	—	—	—	15	9	24	—	1	—
Naval Post-Grad. Sch.	66	—	65	1	34	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		

Harvard	128	—	126	2	138	—	9	—	9	—	8	—	106	—	106	—	25	—
Mass Inst Tech	588	106	692	2	390	—	146	—	146	—	42	—	275	—	275	—	74	—
Northeastern	—	326	323	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester Poly	31	—	31	—	15	—	—	—	—	—	—	—	—	—	—	—	—	—
Massachusetts																		
Mich M & T	17	—	17	—	9	—	—	—	—	—	15	—	—	—	—	—	—	—
Mich State Col	69	—	69	—	20	—	—	—	—	—	—	—	21	—	21	—	1	—
Univ Michigan	349	2	351	—	275	—	—	—	—	—	2	—	143	—	143	—	22	—
Wayne Univ	78	—	78	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan																		
Univ Minnesota	242	—	240	2	107	—	—	—	—	—	2	—	67	—	67	—	14	—
Minnesota																		
Miss State Col	5	—	5	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ Miss	9	—	9	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Mississippi																		
Mo Mines	128	—	128	—	39	—	—	—	—	—	—	—	18	—	18	—	2	—
Univ Missouri	44	—	44	—	20	—	—	—	—	—	—	—	4	—	4	—	—	—
Wash Univ St L	193	—	193	—	26	—	—	—	—	—	—	—	33	—	33	—	—	—
Missouri																		
Montana Mines	18	—	18	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Montana State Col	19	—	19	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Montana																		
Univ Nebraska	29	—	28	1	4	—	2	1	3	—	2	—	—	—	—	—	—	—
Nebraska																		
Univ Nevada	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nevada																		
Dartmouth	25	—	25	—	25	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ New Hampshire	4	—	4	—	8	—	1	—	1	—	—	—	—	—	—	—	—	—
New Hampshire																		
Newark	7	450	455	2	26	—	2	—	2	—	—	—	—	—	—	—	—	—
Princeton	58	—	58	—	33	—	—	—	—	—	—	—	36	—	36	—	4	—
Rutgers	119	—	119	—	19	—	—	—	—	—	—	—	—	—	—	—	—	—
Stevens	26	889	906	9	137	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Univ New Mexico	25	32	57	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
New Mexico																		
Alfred	12	—	12	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly	87	1 039	1 121	5	113	—	—	—	—	—	—	—	37	135	172	—	12	—
Clarkson	8	—	8	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
City Col of N Y	—	151	149	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Columbia	144	198	342	—	119	1	5	—	5	—	—	—	9	—	9	—	10	—
Cornell	84	9	91	2	59	—	—	—	—	—	—	—	67	—	67	—	12	—
N Y Univ	42	671	706	7	182	3	—	—	—	—	—	—	—	145	145	—	6	—
Rensselaer	181	110	291	—	98	—	—	—	—	—	—	—	23	—	23	—	2	—

Total Graduate Engineering Enrollment, by School, October 6, 1950—*Continued*

Institution	Number Enrolled in Work for the Master's Degree: Day Students Full Time and Part Time	Evening and Special Students	Total: Men	Total: Wo.	No. of Master's Degrees Conferred in Eng'g 1949–50: Men	Wo.	Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]: Day Students Full Time and Part Time	Evening and Special Students	Total: Men	Total: Wo.	No. of Post-Grad. Degrees Conferred in Eng'g 1949–50: Men	Wo.	Number Enrolled in Work for the Doctor's Degree: Day Students Full Time and Part Time	Evening and Special Students	Total: Men	Total: Wo.	No. of Doctor's Degrees Conferred in Eng'g 1949–50: Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Syracuse	25	68	93	—	27	—	1	—	1	—	2	—	11	18	29	—	—	—
Union Col.	—	46	46	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Rochester	9	5	14	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Webb	4	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
N. C. State Col.	94	—	93	1	46	—	—	—	—	—	—	—	12	—	11	1	—	—
North Carolina																		
Univ. N. Dakota	5	—	5	—	2	—	—	—	—	—	—	—	3	—	3	—	—	—
North Dakota																		
Case	75	398	468	5	80	2	—	—	—	—	—	—	36	35	70	1	7	—
Cincinnati	24	—	24	—	15	—	—	—	—	—	—	—	15	—	15	—	11	—
Ohio State Univ.	143	—	143	—	143	—	—	—	—	—	—	—	31	—	31	—	29	—
Toledo	—	10	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio																		
Okla. A. & M.	88	—	88	—	40	—	—	—	—	—	1	—	—	—	—	—	—	—
Tulsa	24	—	24	—	26	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Oklahoma	63	—	63	—	41	2	3	—	3	—	—	—	—	—	—	—	—	—
Oklahoma																		
Oregon State Col.	42	—	42	—	26	—	—	—	—	—	—	—	8	—	7	1	—	—
Oregon																		
Bucknell	11	—	11	—	6		—	—	—	—	—	—	—	—	—	—	—	—
Carnegie	40	92	131	1	64	—	—	—	—	—	1	—	57	—	57	—	10	—
Drexel	—	160	160	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	63	—	63	—	36	1	—	—	—	—	—	—	14	—	14	—	7	—
Penn State Col.	118	—	118	—	56	—	—	—	—	—	6	—	68	—	68	—	5	—
Pittsburgh	25	464	489	—	52	—	—	—	—	—	—	—	5	62	67	—	5	—
Univ. Pennsylvania	86	508	594	—	82	—	—	—		—	—	—	51	16	67	—	5	—
Pennsylvania																		
Brown	16	—	16	—	—	—	—	—	—	—	—	—	3	—	3	—	7	—
R.I. State Col.	14	—	14	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhode Island																		

Clemson	9	—	9	—	3		—	—	—	—	—	—	—	—	—	—	—	—
South Carolina																		
S Dakota Mines	12	—	12	—	2	—	—		—	—	—	—		—	—	—	—	—
S Dakota State Col	9	—	9	—	4	—		—	—	—		—		—	—	—	—	—
South Dakota																		
Univ Tennessee	193	—	193	—	16	—	—	—	—		—	—	14	—	14	—	—	—
Vanderbilt	1	—	1	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee																		
A & M Col Texas	105	—	105	—	60	—	—	—	—	—	—	—	20	—	20	—	3	—
Rice	25	—	25	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Southern Methodist	—	69	69		—	—			—	—	—	—	—	—	—	—	—	—
Texas Tech Col	18	—	17	1	2	—			—	—	—	—		—	—	—	—	—
Univ Texas	182	—	182	—	62	—	—	—	—	—	—	—	37	—	37	—	9	—
Texas																		
Utah Ag Col	13	—	13	—	13	—		—	—			—	3	—	3	—	—	—
Univ Utah	32	—	32	—	25	—	—	—	—	—	—	—	21	—	21	—	4	—
Utah																		
Univ Vermont	5	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vermont																		
Va Poly Inst	102		102	—	48	—	—	—				—	6	—	6	—	3	—
Univ Virginia	8	245	253	—	—	—	—			—		—	—	—	—	—	—	—
Virginia																		
Wash State Col	23	—	22	1	7			—			—		—	—	—	—	—	—
Univ Washington	131	—	129	2	94	—	—	—	—		—	—	20	—	20	—	3	—
Washington																		
W Virginia Univ	41	—	41		16	—	—	—	—	—	—	—	8	—	8	—	2	—
West Virginia																		
Univ Wisconsin	114	129	243	—	100	—	—			—	—	—	72	1	73	—	20	—
Wisconsin																		
Univ Wyoming	17	—	17	—	7	—		—	—	—	—	—	—	—	—	—	—	—
Wyoming																		
Catholic Univ	55	—	55	—	7			—	—	—	—	—	—		—	—	—	—
District of Columbia																		
Total ECPD Schools	7 872	7 414	15 227	59	4 705	10	278	11	289	—	150	—	2 342	453	2 790	5	492	—

[1] Other engineering degrees requiring work beyond the Master's degree but less than the requirements for a Doctor's degree

Editorial

President's Report

Throughout the year, the ASEE has been actively working with the Engineers' Joint Council and with Government agencies in an attempt to get a satisfactory solution of the problems of engineering manpower as related to the proposed Universal Military Service Bill. The following developments will be of interest to members of the ASEE.

Engineering Manpower

Your Society has cooperated with the Engineers' Joint Council in the formation of an Engineering Manpower Commission. This Commission was formed to make recommendations relating to "the most effective utilization of engineers in the national effort."

The ASEE representatives, particularly Deans Hollister and Saville, have attended numerous meetings and have taken a leading part in the formulation of the Commission policies. They have performed a distinguished service by bringing the entire technological manpower problem into sharp focus among the agencies in Washington, D. C. Dr. Prentice, Chairman of the ECAC Military Affairs Committee and Secretary of the Commission also deserves credit for his energetic contributions to this important undertaking. The Commission has issued a report and members have presented testimony before Congressional hearings on the UMST Bill.

In addition to numerous detailed proposals, the Commission broadly recommends:

1. The national registration of student engineers and engineers in critical fields.
2. The establishment of a National Engineering Personnel Board to review and classify the registrants, place qualified persons in a "reserve" and make selections from this "reserve" for critical skills in military, civil defense, and industrial occupations.
3. The establishment of programs similar to the war time ESMWT programs.

The report also calls attention to the impending shortage of engineers resulting from reduced registrations in engineering colleges.

The ASEE has sent to engineering colleges over 150,000 copies of the reprint "Acute Shortage of Engineers Seen As Enrollment in Colleges Slumps" published in the New York Times. The colleges of the country, in turn, have sent these out to high school students as a means of increasing freshman enrollments in engineering.

The Engineering Manpower Commission is preparing material to be sent to high school students throughout the country calling attention to the sharp decline in engineering enrollments and pointing out that this offers excellent opportunities for students interested in engineering.

Report of the Thomas Committee

An Advisory Committee to the National Security Resources Board known as the "Thomas Committee" has presented its recommendations relating to engineering manpower. Briefly this proposal would provide for the following:

(a). All qualified eighteen year olds would receive four months basic training after having completed high school education.

(b). A limited number of persons who have completed basic training would be permitted to enroll in ROTC units in the colleges to provide a supply of trained officers for military service.

(c). A limited number of students, selected on the basis of national examination, would be permitted to enroll in a Reserve Specialist Training Corps after they have completed their basic training.

(d). A National Scientific Personnel Board would be established to accumulate and analyze information relating to the industrial and military requirements for scientific manpower. It would also advise on the number of scientific and engineering students to be selected for the Reserve Specialist Training Corps, and would allocate manpower requirements to its own Regional Boards. The Regional Boards would classify persons with scientific and engineering skills who are liable for military service including those in the Reserve Specialist Training Corps and others in the Reserve Corps who have completed the twenty-seven months of military service. A person so classified would be referred by the draft board to the N.S.P.B. for assignment to the military forces, strategic industries, or the colleges for service.

(e). All junior and senior students presently taking science or engineering would be permitted to defer their military service until completion of their college work. Also a limited number of seniors would be permitted to enroll for graduate study, the number of such persons being recommended to the President by the N.S.P.B. Persons so deferred would be required to agree to accept employment as recommended by the N.S.P.B. and the President.

Universal Military Service Bill

The Coordinating Committee on Relations with the Federal Government of the ASEE, under the Chairmanship of Dean Saville, is cooperating with the Engineers' Joint Council in studying the proposals for universal military service. At present, the bill provides that a maximum of 75,000 men would have their military service suspended and would be permitted to return to college after a short basic training period. These persons would be selected by such civilian officials or agencies of the government as the President may designate and shall be selected "from such fields of medicine, the sciences, engineering, humanities, and other fields determined by the President to be in the national interest." A student, whose military service has been suspended, may be required to serve the uncompleted portion of his military service within a period of ten years after completion of his school work, "unless such person performs other military or civilian services in the national interest for a period equivalent to such services." The Engineering Manpower Commission, along with American Council on Education and other educational associations, has recommended that the figure be not less than 75,000 per year instead of a maximum of 75,000.

The Engineering Manpower Commission has recommended that of the proposed 75,000 freshmen annually, between 45,000 and 50,000 should be permitted to study engineering.

The question as to what will happen to students now enrolled in colleges is still under discussion. The original Selective Service Act, of which the new U.M.S.T. Bill is an amendment, gives the President authority to defer persons whose employment in "industry, agriculture, or other occupations, or whose activity in study, research, or medical, scientific, or other endeavors is found to be necessary to the maintenance of national health, safety, or interest." Under this provision, the President could defer any or all students now enrolled in engineering colleges. There has been considerable discussion of the possibility of deferring all college students until they have completed their college work, but there seems to be no positive indication that such action will be taken.

Induction of College Students

The following directive has previously been sent to the deans of engineering colleges. This directive was sent by General Hershey to the local draft boards, relating to the induction of college students:

"Postpone induction for thirty days of all college students who are being graduated at this time and having their statutory postponement terminated for that reason. This thirty day postponement is to enable such graduates to obtain employment in essential industries. Upon showing of such employment, local boards should be requested to re-open the case of such registrants and to consider classification anew."

Educational Testing Service

In this issue is an announcement of new pre-engineering tests which have been developed by the Educational Testing Service. These tests are shorter, less expensive, and easier to administer than previous tests. They have been proven to be reasonably predictive of scholastic success in engineering. It is urged that the deans of engineering colleges and administrators of testing programs give serious consideration to the possible adoption of these tests. The E.T.S. is a non-profit corporation, financed by endowments from some of the leading philanthropic foundations. The organization has on its staff some of the best testing experts in the country. They are responsible for the college entrance board examinations, graduate record examinations, and many other examinations, including several in professional fields. Dr. Pemberton Johnson, formerly Director of the Purdue University Testing program, is in charge of construction of the engineering tests. The Committee on Selection and Guidance of the ASEE is working closely with the E.T.S. This Committee and the officers of your Society feel that a great deal can be accomplished along with the lines of construction of new and better tests as well as establishing national norms if the engineering colleges will support these tests. The E.T.S. has reduced costs to a figure which would be difficult for colleges and universities to compete with on a local scale.

Respectfully,

F. M. DAWSON,
President ASEE

ANNUAL MEETING

MICHIGAN STATE COLLEGE

East Lansing, Michigan

June 25–29, 1951

A Cordial Invitation Awaits—
Michigan State College
Annual Meeting June 25-29, 1951

Michigan State College was a relatively small university before World War II, but it stands today as the eleventh largest institution of higher education in the nation. Not only does it have the student body, but it has the educational philosophy, breadth of curriculum, faculty and physical facilities to match.

Here are some little-known facts about Michigan State College. Enrollment of students reached a post-war peak of 16,243 during the fall quarter of 1949. In the fall term of 1950, enrollment stood at approximately 15,000. Total faculty, including teaching, research and extension, numbers over 2000. Physical facilities on the Spartan campus have grown tremendously since the end of World War II through a vast building program. In the field of inter-collegiate athletics, all-around performance of Spartan teams ranks with the best in the nation. The Western Conference voiced its approval of MSC's athletic prowess when it voted in May, 1949, to accept Michigan State as a member of the Big Ten.

The institution has come a long way since 1855, when it was founded as Michigan Agricultural College, first of its type in the nation. Carved out of the pines in Michigan's Lower Peninsula on the outskirts of Lansing, this institution has a tradition in agricultural teaching and extension work that can boast no equal, for it blazed the trail for the land-grant movement which was to follow in the 1860's. These institutions drew upon the graduates, educational innovations and intellectual philosophy developed at MSC.

In the 1920's, the East Lansing college, boasting an enrollment of nearly 3,000 students, began to flex its muscles and prepare for bigger and better things. After curricula in liberal arts and applied science were added in 1921 and 1925, it was natural that in 1925, the Aggies of Michigan Agricultural College became the Spartans of Michigan State College.

Michigan State is proud of its heritage, and service to the people of Michigan has remained the guiding philosophy of the institution since its founding as the "state college." The 15,000 students in the college classrooms are but part of the broad service philosophy of Michigan State College; a program which extends in all directions to spread scientific knowledge to the far corners of the state.

Through the Agricultural Experiment Station, the Co-operative Extension Service and the Continuing Education Service, an additional 100,000 Michigan residents each year are given assistance and training by the college.

Educational Facilities and Programs

Today, students have a choice of approximately 70 curricula, with 58 of these offering graduate degrees. Among the courses available are agriculture, home economics, hotel administration, chemistry, physics, engineering, medical technology, nursing, police administration, business, art, pre-medicine and pre-law. The administration of these courses is divided into eight main schools. They are: Agriculture, Home Economics, Engineering, Veterinary Medicine, Graduate Studies, Science and Arts, Business and

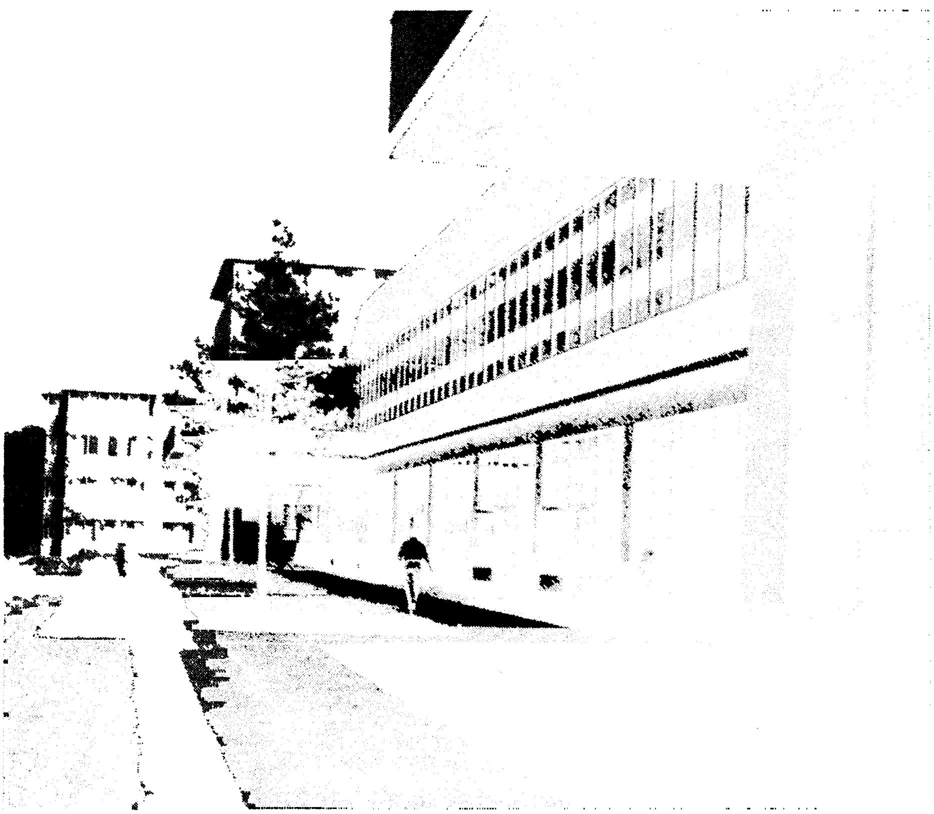
Public Service, and the Basic College, a two-year program of general education.

Although the school is in every way a university, officials of Michigan State prefer to keep the term "college" to avoid confusion with their sister Big Ten member, the University of Michigan.

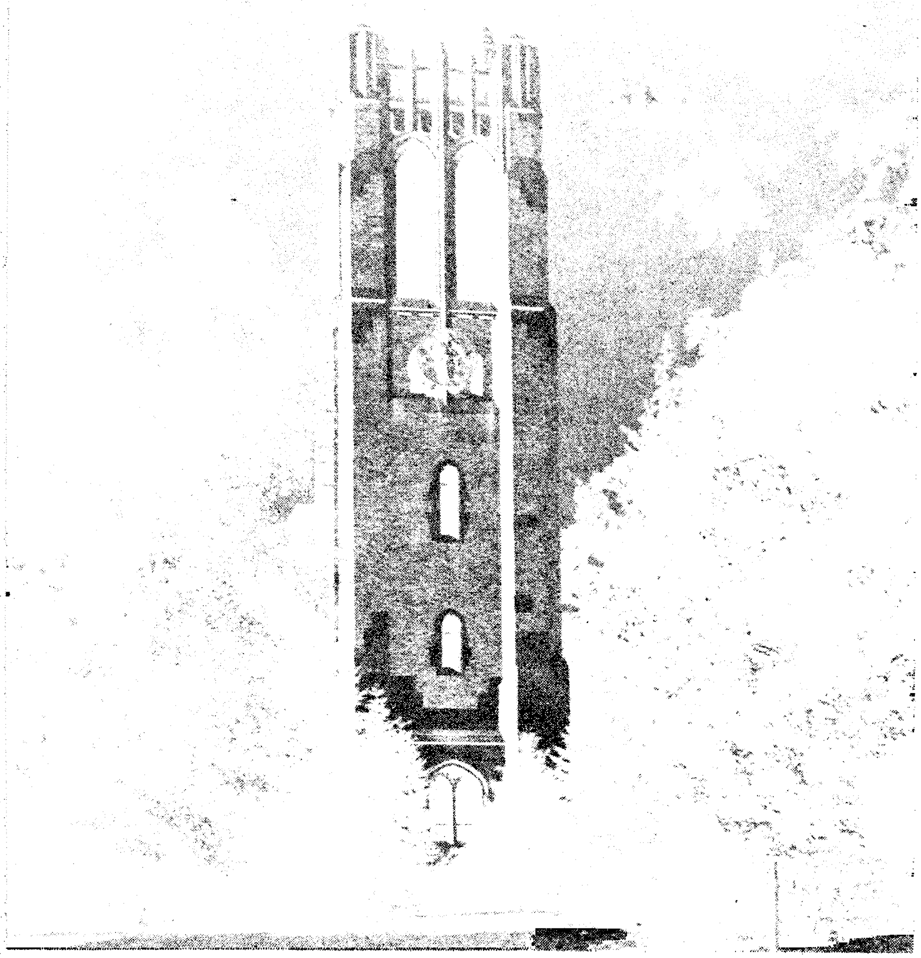
MSC got the jump on most of the nation's colleges and universities in preparing for the post-war rise in enrollment. A self-liquidating program completed in 1940 added eight major buildings to the Spartan campus at no expense to the public.

In 1946, Michigan State launched another building program, designed not only to provide educational facilities for the returning veterans, but also to adequately serve the increasing demands of Michigan people for college educations and numerous other services.

Now nearing completion is a post-war building program which has added 17 major buildings to the East Lansing campus. Also included in the project were modernization of the MSC Union and Macklin Field Stadium, and erection of 11 apartment buildings for married faculty and students. Six large classroom and laboratory buildings, a steam generating plant, seven dormitories and a dormitory food service building have been constructed since the end of World War II. Approximately 60 per cent of



Modern Design: Shaw Hall, newest of five men's dormitories on the Michigan State College campus, accommodates approximately 1600 students. It is one of the largest dormitories in the United States.



Beaumont Tower, most symbolic structure on the MSC campus. Built in 1920, Beaumont Tower stands on the site of Old College Hall, first building in the U. S. devoted to the teaching of scientific agriculture. Its carillon bells have rung students to and from classes for the past three decades.

these structures were built on a self-liquidating basis, at no cost to the public.

Scheduled for completion early in 1951 is the modern seven-story Kellogg Center for Continuing Education. It is being constructed primarily to accommodate more than 100,000 Michigan citizens who come to the campus each year for the college's broad program of adult education. The structure is being financed largely through a grant from the Kellogg Foundation of Battle Creek.

Also included in the post-war building program is an addition and extensive renovation of the college's veterinary medicine facilities. The structure, being built through legislative appropriation, is scheduled for completion in the fall of 1951.

College officials point that the current

construction program, impressive as it is, only makes good in part the accumulated deficiencies of years. Until the current state-financed program was undertaken in 1946, not a single classroom or laboratory structure had been erected on the Spartan campus at state expense since 1931. There is an urgent need for many additional structures, among them a new library building, and an animal industries building.

Although Michigan State has greatly expanded its physical facilities since the war, the natural beauty of the Spartan campus, known the world over, has been maintained. Visitors to the campus are immediately impressed by the careful planning which has preserved the full beauty of such natural landmarks as the Beaumont Oval—its many varieties of trees and expanses of rolling lawn; the Red Cedar river, which divides the main campus from South Campus; the Beal Pinetum, just east of the campus proper; the Beal Botanical Gardens; and the Horticultural Gardens.

Along with its natural beauty, the Michigan State campus has a cosmopolitan personality. Its students come from every walk of life and from every part of the world. Included in its enrollment each year are students from every state in the nation, and from more than 50 foreign countries and U. S. possessions. Even with this wide-spread geographical distribution, Michigan students still constitute about 80 per cent of the campus enrollment.

Michigan State College has always endeavored to maintain a top-flight teaching faculty to administer these courses. The Spartan faculty is studded with national authorities in almost every field.

An important factor in Michigan State's growth has been the dynamic leadership of President John A. Hannah. He has served the college since his graduation in 1923, when he became an extension specialist. He was named secretary of the State Board of Agriculture, governing body of the college, in 1935, and president in 1941. President Hannah is also recognized as one of the nation's top educational leaders, having served as president of the American Association of Land Grant Colleges and Universities during 1949, and as chairman of the organization's executive committee in 1950.

In the field of sports, Michigan State's record demands respect. Not only has the East Lansing school one of the best athletic plants in the nation, but Spartan sports teams have consistently provided better-than-average competition for the nation's top teams. Michigan State engages in intercollegiate competition in 13 major sports.

Macklin Field Stadium has a seating capacity of more than 50,000. Jension Fieldhouse, largest non-commercial building in the State of Michigan, provides approximately 13,000 seats for basketball games, in addition to housing athletic offices and training facilities for other sports.

The 1950 football team ranked 8th in the nation, defeating such teams as Michigan, Notre Dame and Minnesota. Michigan boxers, undefeated in dual competition, copped third place in the 1950 NCAA tournament, following second place ratings in 1948 and 1949.

Spartan swimmers lost but one match, to perennially strong Ohio State, while winning nine meets. The baseball team has a 19–9 record and the cross-country squad won the NCAA crown, after having copped the NCAA, IC4A and NAAU contests in 1948. In all other sports, including several having predominately sophomore squads, Michigan State always proved a formidable foe in spite of won and lost records.

Education for Intelligent Living

By FORD L. WILKINSON
President, Rose Polytechnic Institute

I take my text from a statement made by President-emeritus Hotchkiss of Rensselaer Polytechnic Institute, who in an address before the American Institute of Consulting Engineers several years ago made this statement:

> "I believe that a man should be credited with culture when he has four attributes: when he is able to see in their proper perspective the factors of the problem before him; when he is able to have a true sense of the relative value of men and of things; when he is able to distinguish the true from the false; and fourth, a summary of all, when he has those attributes of a well balanced mind which enable him to live intelligently in his environment."

If the engineer is to become such a cultured man and possess these four vital attributes where may he be expected to commence their development? Does the public school system in which the embryo engineer spends twelve of his preparatory years guide him and interest him in his early march to the attainment of culture? Certainly those of us who meet freshmen each fall have doubts that their major ambitions have been concerned with more than the attainment of sufficient credits in certain courses prescribed for college entrance. These "credits" are largely earned through parrot-like quotations from the texts in use and, like all such learning, immediately lost and irreverently buried. All of this and more is told in a scathing article by Albert Lynd, entitled "Quackery in the Public Schools" appearing in the March issue of *The Atlantic Monthly*. Mr. Lynd goes further and, as far as one of his readers is concerned, brings convincing proof that we can expect little help from the prior education of most of those for whom we must seek to create a desire for the culture of Dr. Hotchkiss.

We in the engineering schools have, and I think quite properly, undertaken the task of the whole education of the engineer. Any by "whole education," I mean that we have assumed the responsibility of offering to the neophyte professional the opportunity to prepare himself to attain "those attributes of a well balanced mind which enable him to live intelligently in his environment."

Potential Leaders of World Thought

I wonder how many of us engineers turned teachers realize how deep that responsibility goes, how extensive that environment is. Is there any phase of human and physical conduct not a factor in the engineer's environment? His whole field, his only excuse for being, impels him to take a vital and necessary part in the political, social and economic betterment of mankind. And his perhaps once limited environment now extends to horizons so broad that we as his preceptors might well lie awake at night and worry over our responsibility, not that he is inadequately versed in the application of nature's laws nor that his technical mistakes will haunt us, but that he is ignorant of all else and cares little how ignorant he is. Our records as teachers of science and technology are unusually good. Engineering has definitely passed out of

* Presented before the Missouri Section, ASEE, April 1, 1950.

the limbo of the empirical arts and into the realm of the rational. I believe that we in the engineering schools and colleges can take pride in being responsible for this tremendous professional advancement.

But we must accept partial guilt, among ourselves at least, of the charge that has been laid before our door time and again of restricting the young engineer's development to the point that his usefulness, influence and interests are not adequately developed for intelligent living. I do not hold with the majority of our accusers that the engineer's education is more stifling than is that of the average liberal arts graduate. In fact, I honestly believe, and think that you will agree with me, that the engineering graduate has a far broader and more beneficial education for himself and for society than does the non-scientific major with an A.B. degree from the average liberal arts curriculum. The point I wish to make here, and to emphasize, is that we have in our student bodies young men whose abilities are such that they may be the leaders of world thought and of world betterment and that we, as engineering teachers, may not be exerting ourselves adequately to that end.

Before the end of World War II this society organized a committee for Engineering Education after the War. I know from first hand that that committee worked earnestly and hard at its task of reporting to the Society. It took to heart all that others had said about our methods and our curricula. It made an earnest effort to analyze the engineer's environment and to suggest certain criteria for the curricula under which engineers should prepare for their profession. As you know, much was said concerning the humanistic-social stem of the engineer's education and the report even suggested that twenty per cent of the curriculum should be devoted to subject matter in these fields.

What has been the result? Meeting after meeting of engineering educators were devoted to the discussion of ways and means of "broadening" the engineering student's education, even as we are doing this evening. Engineering schools in universities with many humanistic-social programs within the liberal arts began pouring over their colleagues' offerings and selecting with their aid those deemed adequate for the broadening of the engineer. A few institutions, being unwilling to sacrifice any hours from engineering or technology, added another year to the curriculum, and one I know of decided that a student must enjoy the broadening advantages of the liberal arts for two years before being admitted to the rigors of the engineering school. Others, not blessed with association on the campus with a college of liberal arts, expanded their faculties in the fields of the humanistic-social studies and developed sufficient new courses to provide the sacred twenty per cent or a reasonable approach to it. On the surface, therefore, the engineer's curriculum has been broadened and he may be expected to acquire through the change a desire and a yen for culture generated in courses gleaned from offerings outside the engineering school or its departments.

Shifting the Burden

Perhaps it is a step in the right direction and I am sure that the hours our students spend in these classes are helpful to them. But, somehow, I think that we as engineering educators have simply shifted the burden of developing the well-balanced mind. We seem to forget that though we may give up twenty per cent of a student's time to non-technical courses and to the instructors in these courses, he spends eighty per cent of his time with us.

Let us concede that four years is an all too short period to provide the technical and scientific background that an engineer must possess to practice in a creative profession. I think that we are properly jealous of every minute of the time that each student spends outside our

individual classrooms. I think that the engineering and science departments are exceedingly generous in granting to others twenty per cent of his valuable time. In fact, I am not too convinced that by this generosity we have strengthened our curricula as media for preparation for "living intelligently" in the young engineer's future environment.

The young man who selects an engineering education does it normally because of his interest in those practices with which an engineer is daily involved. He is inspired by the engineer's accomplishments in solving difficult problems of a physical nature and wants to meet those problems immediately. He, even more than his engineer instructors, resents every hour under the tutelage of any one who is outside the pale of his chosen profession.

I need not tell you that this aspirant for admission to the chosen circle looks upon any problem for which he cannot find or develop a suitable formula as something not worth his effort. I am afraid that we have encouraged him in this and have sometimes belittled the dispensers of culture among our teaching colleagues in the fields of more general education. So while we generously give him up to these gentlemen for twenty per cent of his time, we may perhaps strengthen his resistance to the influences he may receive from them by our own expressions of doubt concerning the value of the hours he spends away from us. Is it not foregone, then, that many students only *suffer* the divergence and look upon the courses they take in the non-technical fields as hours they must successfully pass in order to graduate; hours placed into the curriculum for the sole purpose of providing them with a few courses of less rigor in order that their loads may be somewhat lightened? And woe be the lot of one of our colleagues who teaches a course in the non-technical twenty per cent who should fail a student who stands well in science and engineering!

What I have tried to convey thus far is a doubt in my mind if the shift that we have made in an attempt to better prepare the engineering student for intelligent living has or will result in accomplishing the objectives we all seek and feel to be so important for the well being of all. I am desperately afraid that in shifting the responsibility or the burden, whichever you may feel it to be, to the shoulders of our colleagues outside the engineering school, we have neglected those cultures that we have within our own disciplines. I claim in all sincerity that within the scientific and technical curriculum there exist as many and more opportunities to develop those attributes of a cultured man as may be found in any of the more general disciplines of the colleges of arts.

Our whole professional life deals with an analysis of the many variables that exist in and affect scientific phenomena. We seek to control these variables and to make them perform to the advantage of some good end. We admit to limitations on our knowledge. When we state a law, we establish limits as to its usefulness and all our conclusions are restricted by limitations existing within a clearly stated premise. Is not this the very process through which we may hope to develop in the young minds who sit under us those attributes that enable one to "distinguish the true from the false," to "have a true sense of the relative values of men and of things"? And most certainly our disciplines are most effective in enabling one "to see in their proper perspective the factors of the problems before him."

No matter what the course, or in which collegiate environment it is taught, we have every means of providing a grand opportunity for those who sit under us to develop an analytical approach to every problem they may face. What is it then that may perhaps result in our graduating from the engineering curriculum men of little tolerance and understanding of anything outside the specific courses we have subjected them to? I think perhaps it may be that so intent are we in developing immediate proficiency in a narrow

specialty that we ourselves hardly recognize the complete usefulness of the tools we have at hand.

The danger of our program lies in the fact that we as individuals may not concern ourselves enough with the applications we might make of the methods we use so efficiently. While we are quick to doubt our peers and to exact of them the last ounce of proof in support of an expounded technical conclusion, we permit demagogues in all other walks of life to lead us by the nose and trouble little concerning the accuracy of their statements so pontifically pronounced. Sometimes we even quote as gospel the half-truths from such men as Westbrook Pegler, Drew Pearson and perhaps even Walter Winchell. Too often, we who are the most pronounced advocates of skepticism in the realms of science and technology are unusually receptive to any political, social or economic doctrine that may have a popular acceptance.

Not long ago an old gentlemen of my acquaintance from East Tennessee spent a winter in Washington with his daughter whose husband was a newly elected Member of Congress. He had little else to do than witness our national law makers in action. Upon his return, one of his friends asked him how he had enjoyed his winter's pastime among those who represent us at the seat of our Government. His reply was simply this: "I discovered up there that we have no 'law givers' any more." And I think that one of the reasons we have no "law givers" any more is because in our whole educational system from the primary grades through college, each of us who teaches is concerned too frequently with the problem of indoctrination. Each of us teaches and applies himself to developing in his student the highest possible proficiency in the narrow speciality he professes.

Education or Professional Indoctrination?

Today the average college teacher in English has become a specialist in Shakespeare, Milton or some obscure Elizabethan dramatist, or he may have devoted his life's work to speech or creative writing. The economics teacher may be too thoroughly specialized in finance, accounting or "what have you" in that field. In each of our students we look and pray for one whom we may interest and indoctrinate into the field of our specialized interest, and perhaps only tolerate the others who sit in our classes. Historians are notorious in their specialization so that it is almost impossible to find one sufficiently broadly trained and willing to devote his time to teaching a course that will hold the interest of non-history majors.

With several notable exceptions, when we place our engineering students in the hands of these specialists we only tend to narrow their education rather than to broaden it, and there are some within the ranks of the colleges of liberal arts themselves who declare that their colleges contain a larger majority of specialists than do the professional schools. I think that there is much truth in what they claim.

As I stated earlier in this discourse, we as engineering educators have elected to conduct an undergraduate school at college level. We deem it important that the young men we serve obtain a broad and general education together with their professional. We claim that the rigor of our technical courses is such that only those students with better than average ability may hope to survive. The vast majority of these superior college students begin and end their college courses in our classes. We may say, therefore, that our responsibility goes far beyond providing them with the fundamental educational background that will prepare them for technical proficiency in a limited environment. If we are to serve our nation well and, because of the position it occupies among other nations, the world, we must superimpose upon the technical, those influences that will develop "those attributes of a well balanced mind that will enable him to live intelligently in his environment."

I am definitely convinced that this cannot be accomplished through the implementation of the new curricula we have adopted. We can only succeed if those who teach neophyte engineers for more than eighty per cent of the time adopt an attitude that an engineering education contains as much or more of cultural value than any other. It means that engineering teachers themselves must have or must develop those attributes of a cultured man so adequately defined by Dr. Hotchkiss. We have, within our professional practices, the most wonderful attitudes and disciplines for this purpose. It is only needed that they be extended. Engineering is forever extending the discoveries in the solution of one scientific problem into many others.

This is accomplished by allying itself to no blind doctrine or "school of thought." And this same principle applied to the political, social and economic life, all within the ever-broadening environment of our graduates, can be the only education of the engineer for intelligent living.

I wish to repeat and to re-emphasize that the burden is on our shoulders and not on those to whom we have allotted a limited amount of the student's time, regardless of how great for good their influence may be. Our faculties must be composed of, in addition to men of outstanding technical abilities, men of such broad culture that they contribute the largest share in the development of the well-balanced mind in those young men who, because of the dependence of the world on their technical ability are to influence so largely the future of generations to come.

Inspiration in Education

Since assuming my present position, a little over a year ago, I have met with alumni throughout the country. One of the striking things about these meetings has been the tributes of these men to those who taught them. Some of these alumni are the leaders in business and industry and all of them are graduates of an engineering curriculum. These tributes are rarely directed to the content of the courses taught by the men they admired and revered but to the inspiration they received from their personalities and the intimate association with these great teachers which they had.

Just last week, one alumnus, who is the President of what is probably the world's greatest corporation, told me of the influence on his thinking of a grand old gentleman long since retired. This alumnus graduated as a civil engineer and the professor to whom he referred taught chemistry. He said that the example of this great teacher in the classroom and outside inspired in him the assurance that in scientific and engineering studies there was to be found all that one could need for intelligent and useful living. His life outside the classroom was one of service to the community and the students were justly proud of the respect for his integrity that was evident from the local citizenry. To be able to command that respect and admiration from students means the possession of qualities far beyond mere technical competence. To give of one's self and to inspire to culture and intelligent concern is what may be called the "plus of good teaching." And I think that you must agree with me that it takes that "plus" in the development of the well balanced mind among engineering students.

I entered the teaching profession from industry some seventeen years ago, wholly inexperienced in pedagogy and horribly conscious of my deficiencies. I approached my Dean, whose teaching experience encompassed some forty years, and asked for advice on "how to teach." I recall with what earnestness he said: "I do not know how to advise you. I think perhaps you would do well to look back over your college career and pick out the one among your instructors who inspired you the most, and emulate him." And he went on to say that he believed I should find that he was probably not one who had the greatest reputation as

a scientist or engineer but the one that stimulated my intellectual curiosity more than any other.

There immediately came to my mind a picture of Professor Morse of Columbia University, who, when I was privileged to sit in his classes, had passed seventy years and was teaching only one course. He called his course "The Philosophy of Design" and each meeting was for two hours with a ten minute rest period at the halfway mark.

He taught largely by analogy and into the field of the design of structures and machines he wove a philosophy of professional conduct and responsibility that will always be with me. Many of his illustrations were from nature and he dealt largely with man's efforts in technology to copy many biological processes and improvements. He started a lecture on columns one day by drawing on the blackboard with remarkable skill and from memory the evolution of man's tibia from the skeleton of the Neanderthal man to the frame of the modern. Each lecture was interspersed with morals nicely conceived and subtly presented to impress upon us the importance of a professional attitude of service with all it implies of an ever-widening responsibility beyond that of simple technical competence. And at the end of the term his examinations were all that any purist in the field of design could desire.

In reflection over the years since then I have been convinced that Professor Morse was retained on the Columbia Engineering School faculty long past retiring age because of his proficiency in inspiring those students who sat under him.

While I am ever conscious that I shall never be able to emulate Professor Morse, I do find myself critical of my teaching based on the "plus of good teaching" as exemplified by that grand old gentleman who gained his engineering reputation in 1876 as one of the principal designers of New York's Sixth Avenue Elevated Railway.

The importance of this "plus of good teaching" is greater today than it was a generation ago. I have the impression that in those days the threats to the freedoms we are supposed to enjoy were mild if not inconsequential. The graduates from engineering schools were relatively few in comparison with those from other colleges of higher learning and they could segregate themselves fairly well from those who influenced the political and economic life of the nation. The economy of the nation was far from being almost wholly dependent on the increased value of our materials through manufacture, and it is this influence on our economy that is almost entirely the sphere of the engineer and his brother, the scientist.

Today the products of engineering colleges scatter themselves into every field that influences our national economy and the maintenance of production and employment is one of their major responsibilities. They cannot be segregated from the rest. They must mingle with them and their attitudes and their philosophies will exert greater and ever greater influence on our national economy.

That they may obtain a start toward the acquisition of a well-balanced mind while sitting under us as their preceptors is our major responsibility, not to be shifted to the shoulders of others who I think to be no more capable that we to inspire to intelligent living. Let us not then be so greatly concerned that we pack into the curriculum of the young engineer courses and hours in this or that so-called social-humanistic study, but that we so conduct our classes and courses that the full significance of our great culture will develop men who possess in full measure those attributes of well balanced minds that will enable them to live intelligently in their ever-expanding environment.

God grant that we shall be able to meet this tremendous responsibility.

Educational Patterns in U. S. and England*

By MERVIN J. KELLY

Executive Vice-President, Bell Telephone Laboratories

It gives me pleasure to participate in the discussion of England's problems in higher technological education. I have listened with great interest to the material presented by the previous speakers. It appears that you are almost of one mind that something must be done to provide for the training of a larger number of engineers, but there are differences in viewpoint as to the best course to follow.

It is impossible for one from another country to have adequate background to recommend the educational patterns to be followed to provide your country with a large enough supply of men with the training that is best suited to your industry's needs even though he be familiar with your present organization of engineering education, the institutions where the training is given, and the place of the scientist and engineer in your industrial society. I shall certainly not attempt to do this. Rather I shall confine myself to a presentation of my country's applied science and engineering educational pattern and the place of the scientist and engineer in its industrial society. I shall also make comparisons of the numbers completing an engineering education in America and in your country and give my interpretation of the significance of the difference.

It is now generally accepted that an effective, dynamic and competing industrial society must have adequate structures of pure research in the physical sciences and in applied research, development, design and engineering for manufacture. These structures are built around specially trained men. To provide them there must be an educational system of adequate capacity and quality with curricula suited to the needs of the training of the variety of technical specialists that industry requires.

During the last 50 years there has been a tremendous expansion of industry in America. At the beginning of the century we were primarily an agricultural society. Today we have the largest industrial structure in the world. As a scientist in industry I have observed the last 30 years of this transformation. As industry has expanded and increased its scope, there has been a parallel increase in the volume of scientific and engineering education accompanied by a continuous improvement in its quality.

The two developments have had an intimate interrelationship. I am confident that the great expansion in the volume of our industry with an ever-broadening scope could not have come about had not our scientific and technical education structure undergone corresponding expansion and broadening with great improvement in quality.

In 1920 there were only 4600 engineering graduates in the United States. In 1950 the number was approximately 50,000. (This number is abnormally large due to the effect of war on the education programs of our young men but some 30,000 is the probable normal.) There are now some 137 engineering schools whose curricula meet the mini-

* Condensed version of remarks at the Conference on Higher Technological Education on 27 March, 1950 in the Auditorium of The Royal Society, London.

mum standard of the Engineering Council for Professional Development. (An agency of the Professional Engineering Societies.)

An earlier speaker has quite properly raised a question concerning the number of engineers educated in my country in comparison with the number educated here, even when the difference in total population is taken into account.

If 30,000 is taken as our normal present level of engineering graduates per year, I estimate that we are training of the order of ten times the number of engineers as is England when our population is only some three-fold that of yours. This disparity, I believe, is mainly due to the difference in the area of use of the engineer in the industrial society of the two countries.

Increasing Use of Engineering Graduates in U. S.

We now use the engineering graduate in a considerably wider range of our technological activities than is your practice. Some 30 years ago we used the engineer almost entirely to develop and to design. There were very few engineering graduates in manufacturing engineering, in the supervision of manufacturing operations or in the operations of the service industries such as electricity, gas and telephone. As technology became more complex it was increasingly difficult to realize the maximum benefit from the output of our young research laboratories when so large a fraction of the technological operations were done and directed by men without engineering training. From my own experiences in the early twenties in introducing electronic products into manufacture and use (remember that in the early twenties the electronics industry was in its infancy) I can give testimony to the difficulties of introducing so new, complex and precise an art into a manufacturing organization made up largely of nontechnically trained men.

As these difficulties were recognized, engineering graduates were used in an increasingly large area of the technologic operations of our society. Through the years there has been a continuous increase in the area of use of the engineer in the activities of manufacturing, distribution and technical service. Now substantially all members of manufacturing engineering organizations are engineering graduates and the top few levels of management of manufacture are largely filled by engineering graduates. The distribution of industrial products and consumer goods is planned and directed by engineering graduates. The service industries in their management and technical operations are also manned increasingly by engineering graduates.

This trend toward the increasing use of engineering graduates in all sectors of industrial management and operations is continuing. The progress made in the three decades of my observation is tremendous. It is not surprising to find that with the growing population of engineers in all areas of industrial management and operations the senior man in the direction of a corporation, the president, is also becoming more and more a man of engineering training. The presidents of some of our largest industrial and service corporations are men with engineering training whose entrance to industry was through the door of the professional engineering job.

This broad extension of area of use of the engineer beyond the professional operations of development and design has been one of the most important elements in the rapid increase in our industrial power. I am confident that our technological progress would have been much slower and our country's industrial strength of a considerably lower order if our technical education system had not supplied the large volume of adequately trained engineers for use in the management and technical operations of an ever-increasing area of our industrial society.

If the technically trained man, the engineer, now occupied the same area in your society as he now occupies in that

of my country, it would be necessary for you to increase your engineering graduates by at least a three- to five-fold factor.

Evolution of Industrial Research Laboratory

Since our conference today is primarily concerned with engineering training, I have first discussed the engineering educational pattern and the place of the engineer in my country's industrial society. However, one will not obtain a balanced view of the relation of education to our industrial strength unless the training and place in our industry of the scientist, applied scientist and postgraduate trained research engineer are also presented. We shall now turn to this area.

The industrial research laboratory directed by men trained in the research methods of science had its beginnings in my country in the first decade of this century. Dr. F. B. Jewett of the Bell System and Dr. W. R. Whitney of the General Electric Company were among the first men trained as pure scientists with a working knowledge of the scientific research method. The laboratories they founded have become two of the great industrial laboratories of our country. More men trained in research at the doctorate level followed them into industry and the number of our industrial research laboratories has grown rapidly. There are now some 2500 in our country. In the early years substantially the only source of men for industry trained in the research method was our graduate schools of pure science.

Initially there was some difficulty in industry's obtaining its share of the men of highest quality trained in pure science. The environment that industry has established for them over the years, the freedoms that they enjoy and the monetary rewards are such that for many years industry has obtained its share of the most competent men trained in research in the graduate schools of pure science of our universities and technical institutes.

Initially the needs of industry for men of research were met almost entirely by selection from the graduate schools of pure science. Soon, however, the evolution of the industrial research laboratory accompanied by the growing complexity of technology developed the need also for men of research of the engineering type having more fundamental training in the sciences than can be obtained in the four year engineering course and with experience in research in an academic atmosphere.

This need has been met by the development of postgraduate courses in an increasing number of the institutes of technology and schools of engineering in the universities. Curricula have been developed leading usually to the Ph.D. degree but in some institutions a doctor of engineering is given as the equivalent of the doctor of philosophy. In 1949, 1150 doctorates in the pure sciences, physics, chemistry and mathematics, applied science and engineering were awarded. Approximately 400 were in the areas of applied science and engineering. Most of the 400 have entered the laboratories of industry and government. Also, a significant fraction of the 750 doctors in the pure physical sciences have taken places in our industrial and government research laboratories. While I have not been able to obtain exact data, it is my estimate that at least one half of the 1150 doctors of 1949 have entered research laboratories of industry or government.

The training of the graduate men in the institutes of technology and the engineering schools of our universities has had a most beneficial effect on the undergraduate curricula. The atmosphere of research and the contact at the research level of the faculties of engineering with industry have made for a much more stimulating and fundamental atmosphere in the undergraduate school. The graduate schools in applied science and engineering that are an integral part of an increasing number of our institutes and

schools of engineering and the industrial research laboratories that look to these graduate schools for a large fraction of their young research men are most essential and important links in our chain that transforms new scientific knowledge into facilities for man's use.

Ascendency of Graduate Work

There is evidence that in the more complex areas of industrial technology an even larger fraction of the creative technical staff than can now be obtained from the graduate schools of our universities and technical institutes could well have training beyond the four-year engineering course. The Bell Telephone Laboratories in the years since the war have established an on-the-job school of graduate training where it gives its four-year engineering recruits additional training in the sciences and in the technology of telecommunications at the postgraduate level. While this experiment is too new for final conclusions to be drawn, our experience indicates that substantial benefits will accrue in our development and engineering programs from the additional fundamental training that the young engineers are receiving.

In your plans for higher technological education the importance of graduate training in applied science and engineering to the doctorate level should not be overlooked. The amount of such training has been steadily increasing in our country and, with the continuing trend of greater depth and complexity in technology, industry's needs for such men will grow. I do not believe that a society having available to it only men trained in pure science for its applied science, in engineering research and fundamental development for industry and engineers with the equivalent of our four years of training for its specific development and design work for industry will have the required self-contained strength. It will not move as fast or be competitive with an industrial society that also has available an adequate number of men of the engineering type trained in institutes of technology and engineering schools to the doctorate level and with training in an academic atmosphere in the methods of scientific research.

Including this graduate training in our institutes of technology and schools of engineering is not only providing us with research men well-suited to large areas of industrial research and development but is also having a beneficial effect on the training of the four-year engineering students.

Sections and Branches

The **Kansas-Nebraska Section** of the ASEE held its annual meeting at Kansas State College, October 13 and 14. Dr. James A. McCain, President of Kansas State College, spoke at the opening dinner meeting on "Technological Trends in the Twentieth Century." Dr. McCain pointed out a scientific method of predicting what new inventions could be expected to have the greatest effect upon our civilization in the next ten years.

A panel discussion was held on the topic: "Objectives in Engineering Education, and Some Effective Methods for Realizing These Objectives with Emphasis on the Professional Orientation and the Citizenship Responsibilities of the Individual Engineering Student."

The following men were elected to office: President, K. Rose; Vice-President, J. K. Ludwickson; Secretary, J. N. Woods; Representative to General Council, D. G. Wilson.

Nuclear Engineering

By D. W. CARDWELL
Oak Ridge National Laboratory, Oak Ridge, Tennessee

EDITORS NOTE: *The following papers were presented at a Symposium on Nuclear Engineering held by the Southeastern Section of the ASEE, August 20–23, 1950.*

I think that questions which trouble engineering teachers most as they explore the atomic energy field run like this—"just what does a mechanical engineer do in this business, where does the chemical engineer fit in, and what kind of assignments do you give to your electrical engineers?" It is not easy to answer questions such as these directly because we purposely have developed a melting pot wherein we can take advantage of the important abilities and experiences of each of these professions in concentrated efforts against problems which spread across many specializations. We do find, however, that engineers of different specialized backgrounds are making the greatest contributions along lines closest to their previous training and experience. So I will do what I can to separate these for you with the hope that as you teach your conventional courses you will at least be able to provide some illustrations for your students which would give them an idea as to how they might fit into our activities.

Functions of Mechanical Engineers

Let us consider first the mechanical engineer because I believe at the present time people of this training prove to be widely useful in many branches of the atomic energy field. Our mechanical engineers are playing an important part in the design and development of nuclear reactors. We have found that the reactors built during the war merely scratch the surface and point to the interesting possibilities of a wide variety of possible machines which may be used for different purposes. Following an unfortunate period of indecision after the last war we are at last embarking upon an extensive program for the development of a number of these machines which may soon propel naval vessels, power airplanes, generate useful electric power, and produce fissionable materials and radioisotopes in large quantities. Mechanical engineers are designing and building components of reactors such as fuel elements, moderator blankets, reflectors, control rods, heat exchangers; and, an amazing array of special handling devices which can move objects in and out of the active lattice without endangering operating personnel.

Mechanical engineers wrestle with problems of fluid flow, heat exchange, and thermodynamics where new materials provide intriguing possibilities. While employing conventional design techniques they must be ever conscious of the effects of high density neutron fluxes; Alpha, Beta and Gamma radiations. Along with nuclear reactors must come extensive radiochemical processing plants. It is usually necessary to process the fissionable fuel such as uranium before it goes into the reactor and after the reaction has taken place materials are withdrawn and run through complicated separations processes in order to segregate various desirable and undesirable products. Me-

chanical engineers are busily engaged in developing pumps, valves, jets, agitators, and evaporators to fit into these chemical plants.

Much of this equipment starts according to conventional standards but must be adapted for the unusual nature of the materials flowing through the process. These materials are generally quite radioactive, highly corrosive and can not be concentrated in greater than certain maximum quantities. Engineers must take industrial indicating instruments and automatic controls and fit them into these processes so that they can be operated safely and efficiently.

A field of growing interest to the mechanical engineer involves the design and development of devices which can perform certain standard functions when separated from the operator by concrete walls several feet thick as protective shielding. At Oak Ridge National Laboratory we have just completed design of a remotely operated machine shop for a new hot laboratory where radioactive specimens will be handled in their solid state as a part of basic and applied research programs. Unusual devices are being developed which allow operators to view the activities within these cells. We have periscopes, remotely viewed miscroscopes, and windows three feet thick which are actually glass tanks filled with a very heavy solution, zinc bromide. People at the Argonne National Laboratory in Chicago have developed stereoptical television which requires a minimum of penetrations through concrete shielding walls and yet allows an operator to perform his experiments with complete depth perception on the television viewing screen. In our isotope production plant we uncap bottles, accurately pipette measured quantities of active solutions into smaller bottles, and package these for shipping to our customers. All of these operations must be handled by means of complicated remotely operated mechanical equipment.

In the field of high voltage accelerators where massive new machines are being constructed in various parts of the country mechanical engineers are playing an important roll in the design of vacuum tight tanks, carefully shaped electrodes, and unusual auxiliary mechanical equipment. Just now we are confronted with an extremely difficult problem of electrode fabrication for our Van de Graaff generator which reaches all the way from the complicated subject of electromagnetic field theory through mechanical design down to the machinists in our shops.

Electrical Engineering Problems

Electrical engineers find their principal connection with nuclear reactors in the development of automatic controls for these machines and in providing radiation measuring instruments. Before very long we may find electrical engineers playing another important role, that of producing power from generators which may be driven by nuclear powered turbines. The control of nuclear reactors is an extremely important field. Whenever we assemble an appreciable volume of fissionable material there is an accompanying hazard which if not properly recognized and handled can cause considerable damage. In order to be able to develop reactor controls our electrical engineers must learn quite a bit about reactor theory from our nuclear physicists. However, the devices which we develop are made up of conventional components which can be found in servo-mechanism gun turret control systems, radar transmitters, etc. When we feed into this control system the pile equation we must train it to react in the manner which we prescribe. To accomplish such an objective we employ motors having extremely rapid response to signal change and electronic amplifiers with feedback loops to insure stability. Such a system must then be adapted to mechanical drives for the reactor control rods.

Much of our work in the atomic energy field is dependent upon having reliable radiation measuring instruments. Certain features of our reactor operations and our chemical processes must be auto-

matically controlled by these devices. Radiation detection instruments of another type must always be handy in sounding an alarm in case radiation levels exceed human tolerance. Probably the most important use of our extremely accurate radiation instruments relates to their use in basic research. The nuclear physicists and frequently the radiochemists and the biologists obtain practically all of the intelligence from their experiments by means of radiation instruments. These instruments employ primary detectors such as ionization chambers, Geiger-Mueller counter tubes and rare crystals to produce the original electrical impulses. From here on out, however, problems in this field become problems of electronic circuitry which are familiar to the radio engineer. High speed counting circuits are used, somewhat similar to those employed in analogue computers, and wide-band amplifiers are developed which use many of the techniques that have been developed in the radar industry.

In the high voltage accelerator field, electrical engineers are depended upon to design and develop external power supplies, and many internal features of the machines themselves. Scientists are today exploring high energy levels using synchro-cyclotrons, linear accelerators, betatrons, and Van de Graaff machines which are placing requirements upon electrical engineers that are indeed challenging. Electrical power supplies have been developed which deliver thousands of volts at high currents under carefully controlled conditions. Some of these power supplies must be regulated to provide extremely smooth direct current. Others must be made to oscillate through a wide range of frequencies. Here again conventional components are put together in a fashion to meet these requirements. Our larger power supplies use vacuum tube rectifiers originally built for radio broadcast transmitters and the conductors between these power supplies and the accelerator machines employ cables made for the x-ray industry capable of withstanding the extremely high voltage involved. Insulation within the units themselves presents extremely difficult problems involving gas discharge, corona, and various forms of ionization.

Chemical Processes

Our chemical engineers, as would be expected, make their major contributions in the development of chemical processing plants for handling radioactive materials. Well-known methods are adapted to our special requirements involving acid dissolvers, solvent extraction columns, evaporators, etc. Design engineers must be continually conscious that the entire process must be assembled and operated in closed concrete cells in order to confine dangerous radiation. We are in a continually never ceasing business in Oak Ridge of developing methods for separating various elements and compounds which are important to our program. Some of these elements in the range of uranium and above, on the periodic table, represent materials about which there was little known before the last war. Our chemists continually experiment with these elements and work out means in tabletop glassware scale for performing certain operations. Chemical engineers then develop flow diagrams for new processes which can be expressed in terms of pilot plants composed of stainless steel tubing, tanks, agitators, scrubbers, etc. These pilot plants are tested and operated, and improvements are developed on them before proceeding to full scale projects which may take place at one of the large atomic energy installations either at Oak Ridge or away from Oak Ridge. Our chemical engineers are playing an important part in developing facilities for the manufacture and handling of radioactive isotopes which are finding such wide spread usage throughout the country.

There are some interesting new developments in the nuclear reactor field which are making further demands upon the skills of chemical engineers. It is now thought possible to make many of the

reactor components take liquid form rather than mechanical form thereby gaining certain advantages. Chemical engineers are assisting with the development of these new ideas which should have some physical realization before long.

Civil Engineering Contributions

The civil engineering profession is making significant contributions in certain phases of the atomic energy program. We have many problems involving unusual structures where we use conventional material such as reinforced concrete and structural steel to provide mechanical stability to nuclear reactors, radio-chemical processing plants, and special research laboratories. Although much of this design proceeds according to standard handbook information it is necessary for our engineers to learn quite a bit about the special features of radioactive materials so that they can be properly accommodated. The design of a series of hot cells, made chiefly of concrete, lead, and steel represents an interesting undertaking. Here, we are not interested so much in the strength of concrete as we are in its density to provide these radiation proof walls. We are actually employing special aggregates now such as barytes which can produce a special heavy concrete which for a given thickness may provide from 50 to 100% more effective shielding than conventional concrete. The handling and placement of this heavy concrete mix provokes some unusual field construction problems and the carpentry form work involving penetrations for periscopes and viewing windows, handling devices, etc. becomes rather complicated.

It must be remembered that various engineering materials can react quite differently in fields of Alpha, Beta, Gamma, or neutron radiations and our engineers must learn what these unusual characteristics are so that our designs may be not only effective but efficient and economical. We have, of course, employed civil engineers for conventional field surveys to initially locate and layout new projects and this is all accomplished by conventional engineering methods. Our field engineers are learning many of the unique characteristics of atomic energy work because frequently these characteristics will have an important bearing on the determination of appropriate site selection and structure orientation for a new project.

Engineering and Science

Now that we have reviewed the place of some of our more important engineering classifications in the atomic energy field we can draw one or two quick conclusions about the qualifications which are needed for this work. First of all our personnel must be well grounded in the basic training of their profession. Too often, I think, people would attempt to completely convert engineers into scientists for this work. It is true that our engineers must understand more basic science than usually required for other fields, and this is important, but they can never assume what are the proper responsibilities of the chemists, physicists, metallurgists, etc. There is a vast storehouse of knowledge and experience in the engineering profession. Our engineers must continue in close contact with this storehouse so that they can make it always readily available as an aid to scientists whose necessary specializations keep them somewhat remote and removed from this information.

In the atomic energy business there is not much room for people who are content to be simply "handbook engineers." Much of the design information which we use has never appeared in any handbook and it is doubtful that any time in the near future we will have a breathing spell in the urgency of our efforts which will allow for the preparation of complete handbooks. Also, the findings of our research people are so rapid and significant that design data useful today may be completely useless tomorrow. Frequently, training of engineers is directed toward making them capable of step-by-

step duplications of previous designs without complete knowledge of basic theory. Without a good grasp on basic theory, engineers in the atomic energy business have a difficult time, because we seldom make a chinese copy of a previous structure. Sometimes in the past we have been such slaves to "standard practice" that we cannot recognize where modifications are justified, and even demanded, to insure minimum cost and proper functioning. There are many, many examples that could be cited where failure to recognize the unique requirements of atomic energy installations have caused an immense waste of time and money. This situation could be greatly improved by educating engineers toward a better understanding of certain basic fundamentals which would enable them to properly adapt conventional engineering equipment to meet our needs.

Programs of Oak Ridge Institute of Nuclear Studies of Interest to Engineering Faculty and Students*

By WILLIAM G. POLLARD

Executive Director, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

Dean Ernst has reported to you on the national and regional plans of the ASEE for the development of closer and more active relations between engineering educators and the Atomic Energy Commission. As he pointed out, a number of the problems considered by the national group are already provided for in our region through the various programs for university participation in Oak Ridge facilities which have been developed by the Oak Ridge Institute of Nuclear Studies. It is my purpose to report to you briefly on the plans and programs of the Institute which are of interest to the engineering profession.

Summer Symposium on Engineering in Atomic Energy

As the final portion of the programs on nuclear engineering arranged by the ASEE as reported by Dean Ernst, the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies plan to devote their summer symposium for 1951 to the subject of Engineering in Atomic Energy. These summer symposia are a regular part of the programs of the University Relations Division of the Institute. Last year the Symposium was devoted to Modern Physics and this year to Modern Chemistry. These symposia are typical of a number of activities carried out cooperatively by the Laboratory and the Institute in the interest of scientific advancement and the utilization of the special facilities of the National Laboratory for educational purposes. Although they are intended primarily for Oak Ridge and Southern University personnel, persons from outside the region are cordially invited to attend insofar as facilities permit.

Sessions of the symposium are scheduled four mornings per week, Monday through Thursday, for two weeks. The Symposium on Engineering in Atomic Energy will be held August 27 through September 6, 1951. All afternoons and the intervening Friday and weekend will be free for informal discussion or to allow visitors to take advantage of the varied recreational factlities around Oak Ridge. This intervening period would also be available for a meeting similar to this Fontana Conference if this is desired next year. Attendance at the symposium will be without charge to the individual, although each person is expected to pay his own travelling and living expenses. The detailed program and speakers will be announced later, probably soon after the first of the year.

Research Participation Program

Another program of the University Relations Division of interest to engineering educators is the Oak Ridge Research Participation Program. This program is also conducted jointly with the Oak Ridge National Laboratory. Application for the program is made by a participating institution on behalf of members of its

* Presented before the Southeastern Section, ASEE, Fontana Village, N. C., August 20–23, 1950.

scientific or technical staff for research in fields where special facilities of Oak Ridge laboratories which are not available at the institution are required for the work. Application for the program is made through the University Relations Division of the Institute and successful applicants are employed by the laboratory in which their research is to be carried out at a salary in accord with the participant's current salary at his university. In special cases, however, an Oak Ridge Research Fellowship may be granted by the Institute in lieu of a laboratory salary. A limited number of these positions are available in the several engineering fields.

This program has become one of the most extensive of those carried out by the Institute. This summer there are seventy-eight research participants from universities of the region carrying out a great variety of research and development programs in all of the scientific fields represented by the activities of the several Oak Ridge laboratories. Any university staff member interested in the program should file an application through the Institute Councilor or the graduate school Dean. Necessary forms are available on request to the Division.

Oak Ridge Graduate Fellowships

The Oak Ridge Graduate Program has been established in order to make available to universities for their own graduate programs the unique research facilities of the Atomic Energy Commission at Oak Ridge. There are two types of Oak Ridge Graduate Fellowships available to students. One is at the master's level and is designed particularly for master's thesis work in engineering and metallurgy. The other is at the doctoral level and fellowships of this type are available in all scientific fields. In each case a requirement of the program is that each student complete all resident work at his university so that only the thesis research is performed at Oak Ridge. After completion of all course work at the university, Fellows at the master's level receive appointments for from six to nine months at Oak Ridge and those at the doctoral level for from one to two years.

Any student at the required stage of his graduate program may apply to the Institute for an Oak Ridge Graduate Fellowship through the Dean of his graduate school or other official in charge of graduate studies. The stipends carried by these fellowships range from $1,500 to $2,700, and are determined by the level of the Fellows' training and number of their dependents. Every attempt is made to arrange a program that can be acceptable to any student who is prepared for advanced training, and on a basis entirely satisfactory to his university. Each Fellow works under the direction of a three-member graduate committee, two members of which are appointed from the Laboratory staff and the third member from the university in which the student is enrolled. Arrangements are made by the Institute under which the university member comes to Oak Ridge several times a year for meetings of the graduate committee with the student in the laboratory where his work is carried on.

At the present time there are four of these Fellows in Oak Ridge working on master's theses in Metallurgy and one working on a doctor's thesis in Chemical Engineering. It is hoped that the engineering faculties throughout the South will become familiar with this program and avail themselves of it for their students when the nature of the research interest makes this appropriate. Application forms for this program are available through the University Relations Division.

Radiological Physics Fellowship Program

The greatly expanded use of radioactive materials which has developed as a result of the atomic energy project has created urgent needs for personnel capable of developing and carrying out procedures to insure protection against radiation exposures. This need has been

a primary one within the Atomic Energy Commission installations for some time. By now it is making itself felt to an ever increasing extent in many other places such as hospitals, universities, and industries which use sizeable amounts of radioactive materials. The rapidly developing requirements of the national Civilian Defense Program makes this need even more urgent.

As one way of contributing to the severe shortage of competent personnel with specialized training in this field, the Commission has established a number of fellowships for training in this field at the first year graduate level. These fellowships are administered nationally for the Commission by the Oak Ridge Institute of Nuclear Studies. This year forty Fellows were selected and arrangements have been made for the provision of suitable academic training at two universities. Twenty of these Fellows are being sent to Vanderbilt University and the remaining twenty to the University of Rochester. Each group spends a full academic year of nine months at the university in a specially designed first year graduate curriculum in radiological physics. Following this period, the Fellows from Vanderbilt are sent to Oak Ridge National Laboratory and those from Rochester to Brookhaven National Laboratory for additional study and training. During this period some of the Fellows may be selected to carry out a master's degree thesis research project. Those so selected will have their fellowships extended for a maximum of six additional months for the purpose of completing their research. Their degree will be granted by Vanderbilt University or the University of Rochester, depending on the group to which they belong and provided the theses are acceptable.

A number of the applicants for fellowships this year were engineering students. The fellowships carry stipends of $1,600 to $2,600, depending on the number of dependents in each case, and travel expense and university fees are reimbursed. Radiological Physics offers a promising career to students with an interest in this type of work. Electrical engineering graduates in particular are likely to find it an attractive field in which to work, and will in general possess an adequate undergraduate background for this program. Further information concerning this program can be obtained by writing to the University Relations Division of the Institute.

Traveling Lecture Program

A final activity of interest to engineering schools is the traveling lecture program. The Institute schedules scientific lectures to be given by the research staffs of the Oak Ridge laboratories and of the Institute itself, without expense to the universities. A regular circuit of lecturers is in operation from Oak Ridge to the various universities and research centers in the South. A list of subjects available this season and forms on which to request particular lectures may be obtained from the University Relations Division.

Engineers for the Atomic Energy Industry*

By PHILIP N. POWERS

Formerly—Advisor on Scientific Personnel, U. S. Atomic Energy Commission
Now—Manpower Specialist (Scientific Personnel) National Security Resources Board

Developments in atomic energy depend upon sound engineering just as do those in any other industry. The separation between research and application seems to be shorter than ever and the need for skilled engineers to work cooperatively with scientists is correspondingly greater. Teamwork between the two can produce devices or processes which not only make use of the latest research findings, but which will also actually work.

Since the war, the proportion of engineers working on technical phases of the atomic energy program has gradually increased. Out of the 8000 or 9000 scientific and technical personnel now working for the Commission and its contractors on research and development, but not counting construction, about half are engineers. Of these, approximately 1400 are chemical engineers, 900 are electricals, 800 are mechanicals, and about 500 of the rest are civils.

Unique Problems of Nuclear Engineering

To the students and teachers in engineering colleges, questions immediately arise about what all this means to them. In planning this meeting, Dean Wessman stated clearly some of the questions in relation to education at the graduate level. He asked:

"What kind of nuclear courses should be given to engineers? Do the present courses given in most universities in nuclear physics answer the requirements for engineers? Is additional mathematics necessary? Do the engineers need a course in 'hot chemistry'? Would existing graduate courses in engineering have to be modified appreciably for nuclear engineering students? Would new specialized graduate courses be required in each field of engineering, such as a course for mechanical engineers in heat transfer problems of reactors, or a course for sanitary engineers in disposal of radioactive wastes?"

To answer these questions it is necessary to consider together actual engineering problems in atomic energy and the training engineers ordinarily receive at the present time. On the latter point, of course, none are better informed than members of ASEE. Suffice it to say, that although the training of engineers is fairly well standardized, there is, as there should be, a considerable variety and flexibility in courses offered, depending upon special interests of both students and teachers.

To go back to the first point of considering actual engineering problems in atomic energy, there are some difficulties. The security question comes up immediately and is indeed tough. But part of the reason for its toughness is that it has been exaggerated. There is a great deal of available information about engineering in the atomic energy industry, more than is generally realized. The availability of this information is known to some members of ASEE, but there are many, I suspect, who have had only limited opportunities to look into what is either non-classified or declassified.

* Presented before the Division of Graduate Studies at the Annual Meeting of the ASEE, Seattle, Washington, June 22, 1950.

It is not possible in this presentation to give much detail about what is available, but I shall quote some examples cited recently by Mr. Wilbur E. Kelley, Manager of the New York Office of the AEC. With reference to his own specialty, civil engineering, he said that in atomic energy "we're asking for buildings with heavy walls, with heavy steel plate laced into them. We ask for concrete and steel tanks that won't leak a single drop—ever. We want sewers that won't corrode—filter beds containing tiny organisms, that, in effect, eat radioactivity and thereby concentrate it for easier handling."

In the mechanical and metallurgical fields, he stated that atomic energy industry "needs designs of pumps that work at higher pressures—that will handle corrosive fluids and gases with little maintenance. We need piping that won't leak—values that are so tight that a few stray molecules will have trouble getting by. We need designs of equipment that will turn faster than the velocity of sound at extremes of high and low temperatures. We need construction materials that will be safe and strong at − 450° F. and some at 4000° F. We need equipment so simple that it can be operated and maintained from behind a ten-foot wall. We may also specify that because of special nuclear requirements the structural material for one of these gadgets must be selected from three or four elements of nature—none of which has ever been used as a structural material before."

There are many other examples. With reference to chemical engineering, Mr. Kelley remarked: "We tell him that processes have to work with 99.999% efficiency. We ask for the last thousandths of an ounce of material from 30,000 gallons of solution and then tell him he can't go near the tank to see the process in action. He has to do it with mirrors! We tell him to sift the chemical gems from hot ashes and not to miss any. He has to develop ways of analyzing for one part of a material buried in a million parts of another."

The combined structural and nuclear requirements for materials are bringing into large-scale use rare metals which have been scarcely more than curiosities before. Heat exchange problems are under study which make the temperatures within engines in use today seem very moderate indeed. This could go on at length through problems of "hot" laboratories, disposal of radioactive wastes, purification of water supplies, and so on.

In all of these examples, there is obviously much rich engineering material. There are some unusual wrinkles in the problems, but basically they have to be worked out in terms of the standard fields. There are new chemical separation problems, but the process is going to depend upon chemical engineering. A high order of ingenuity is required, but fundamentals remain indispensable.

With such a variety of problems, it seems unlikely that the needs of the atomic energy industry can be met through establishment of specialized courses to deal with them separately. In the first place, it is doubtful that there will be sufficient numbers of engineers working on any particular problem to justify such training; and in the second place, it is more important that they learn the basic principles so that they may then cope with whatever problems arise. To me it seems unlikely that a special course on "Heat Transfer of Reactors" should be added, but perhaps heat transfer courses in general may be much enriched through some consideration of special reactor problems, not so much in order to train experts in reactors as to train engineers competent to deal with unusually complex heat transfer problems.

Referring back to the questions about graduate training for atomic energy work, it is clear that they can only be answered by the teachers. There is so much variety in atomic energy engineering, as well as in graduate curricula, that the best answers lie in the judgments of teachers who know the students, the

fundamentals needed for the various engineering fields, and the kinds of engineering problems in atomic energy which are important. To make these judgments, engineering faculties must of course have as intimate an acquaintance with the atomic energy industry as possible. On this basis, their collective answers to questions about courses and curricula will be far superior to any specific answers that I could offer.

ASEE–AEC Cooperative Program

But to help in making the needed information available to engineering faculties, a cooperative program between ASEE and the AEC is now getting under way. Specific ways in which such cooperation can be carried out was the subject of discussion at a recent meeting in Washington attended by AEC representatives and by the ASEE Steering Committee on Cooperation with the Atomic Energy Commission.

At this meeting the special interest of the Commission in strengthening the country's total supply of scientific and technical personnel was pointed out along with the specific need for engineers with training and experience somewhere in between the traditional fields of science and engineering.

Those present agreed that the problem of getting more declassified material, as well as recent developments never classified, into the hands of engineering faculties could best be approached through regional programs of various kinds. The Committee was assured by the AEC representatives present that cooperation on a regional basis would be both desirable and feasible. Further study is now being given to the problem by both the ASEE Committee members and the AEC staff in the regions centering about New York, Chicago, Hanford, Berkeley, and Oak Ridge.

In addition to his questions about graduate curricula, Dean Wessman inquired about this problem of getting materials into the hands of teachers. Specifically, he asked:

"Where would text books and other source material be obtained? What would be the teaching staff requirements? Could special training programs for teachers be instituted at Hanford or other centers of atomic development? Could existing trained scientists and engineers with the AEC be loaned to the university to give graduate instruction?"

These questions illustrate very well some of the matters which will be under study by ASEE and AEC representatives in each of the five regions. Depending upon local circumstances, it is likely that different answers will be found in each instance, but the over-all result will be increased availability of material and more frequent contacts between engineering faculties and the atomic energy industry.

In partial answer to Dean Wessman's questions, however, I can name several sources of information. In addition to articles published by Project scientists in the regular professional journals, the AEC operates a small plant to print, for public distribution, copies of reports suitable for dissemination, but not otherwise published. These documents are now being sold by the Document Sales Agency, Technical Information Division, Oak Ridge, Tennessee, but as of July 1, 1950, the sales operation is being transferred to the Office of Technical Services, Department of Commerce, Washington, D. C.

The Technical Information Division also issues a journal of abstracts covering the Project literature and the published literature both from foreign and domestic sources dealing with nuclear science. This journal, appropriately called *Nuclear Science Abstracts,* is issued semi-monthly and is extensively indexed. *Nuclear Science Abstracts* is also available to the public on a subscription basis from the Document Sales Agency or the Office of Technical Services. It is one of the best present day guides to nuclear information.

The compilation and publication of a comprehensive account of atomic energy developments is another service rendered. Of prime importance in this respect is

the *National Nuclear Energy Series,* a cooperative project among the contractors and the AEC for the preparation of an extensive description of many of the war-time and post-war developments of the atomic energy Project. The books in this Series are written by Project scientists, edited and composed by the AEC, and published by the McGraw-Hill Book Company under a contractual arrangement. Fourteen books in this Series have already been published. The complete series as planned will include approximately sixty books for publication.

As examples of other compilations of information developed on the Project, there is the *Trilinear Chart of Nuclear Species*, a very detailed isotope chart being published by John Wiley and Sons. A *Handbook on Aerosols* is now being published by the Commission through the Government Printing Office. This Handbook is a group of chapters selected from the Summary Technical Report of Division 10 of the National Defense Research Committee which were declassified by the Army at the request of the AEC. A book entitled, *Effects of Atomic Weapons* is now in press at the GPO, and another book, *Sourcebook on Atomic Energy* written by Dr. Samuel Glasstone will be published by a commercial publisher before the end of the calendar year.

Last, but not least, the famous *Smyth Report* remains one of the outstanding documents for explaining the basic science and indicating at the same time some of the requirements which have to be faced in atomic energy engineering.

There is still another kind of question which students and teachers raise about what atomic energy developments may mean to them. They would like to know if there are careers to be had in this new industry, and if so, how many. Specifically, how many atomic energy jobs are available for this year's graduates?

Engineering Era in Atomic Energy

Certainly, engineers may find careers in this new industry but the number of such careers cannot be stated because the industry cannot really take shape until engineers get in there and demonstrate that atomic-powered engines may be made to work. We are at that stage in the development of an industry when no one can say with certainty that the problems are going to be solved, nor can accurate estimates of expenses be made, nor can we even be certain that the present approaches to these problems are correct. A great deal depends upon whether "breeding" can be made to work or not. The theory seems to be all right, but engineers are needed to see if it is really practical to convert uranium-238, useless for power, into fissionable plutonium, and to do it in the course of a chain reaction in which the fissionable atoms will be created faster than they are split. This will be a nice trick since, in theory, while producing power the supply of uranium useful for atomic energy may be increased by a factor of 140. Obviously, such a "breeding" process would go a long way toward reducing costs of atomic power.

It occurs to me that it has not been so long since the television industry was at a similar stage. The answers were not in. There were some who felt that television never would be practical, and no one could say with assurance that it would grow to the point of providing appreciable numbers of careers for engineers. Nor could any one state how many jobs the industry was going to support. Yet engineers moved in on the problems, and an industry grew faster than even most of the enthusiasts predicted. Engineers went into it on faith, I suppose, that they could make the thing work.

Similarly, it is not possible to say how many atomic energy careers are available for engineers. For those with enthusiasm for meeting the challenges of all of these new and tough engineering problems, careers are to be had. Although at the moment the number of persons involved is certainly not large by ordinary industrial standards, it is clear that for the present and the foreseeable future the most serious limitation on progress in

building the atomic energy industry is manpower. Engineers with enough training in fundamentals to take over from the physicists and chemists and to bridge the gap between theory and practice are urgently needed.

In an attempt to reduce this limitation, the Commission has recently established a School of Reactor Technology at Oak Ridge. In an interim session starting last March it provided special training for engineers already assigned to projects on reactor development. Although much of their training has been devoted to fundamentals, they are of course able to go deeply into the classified aspects of reactor design.

To help increase the supply of engineers with such specialized training on a longer-term basis, the School opens formally this fall with about twenty-five recent college graduates enrolled with another twenty-five persons already employed on reactor projects. In general, the curriculum over a period of a year will include some mathematics review through differential equations, some elementary nuclear physics, followed by reactor theory, materials problems, including some solid state physics and radiation chemistry, radiological hazards, details of reactor design, and considerable laboratory work. More details on this curriculum are available, but since this is the first year of the school, it is definitely experimental.

This school represents a quick approach to the manpower limitation problem, but in the long-run, it's the job of the engineering schools to train the needed engineers. The important point is that the engineering faculties must have enough information about the present status of the atomic energy industry to determine to their own satisfaction what should be included in their courses and what new courses, if any, are needed. As they learn more about the engineering problems, they will, I believe, decide that the engineers who will contribute most will be those who understand the fundamentals of their own fields well enough to help bridge the traditional gap between the scientist and the engineer. The engineering faculties will also decide, I believe, that there is much in atomic energy engineering which can be used to strengthen and enrich the standard courses.

Sections and Branches

The **National Capital Area Section** of the Americal Society for Engineering Education held its Winter Meeting on Tuesday, February 6, 1951, The **George Washington University** serving as host. After a brief business session, Russell B. Allen, Chairman of the Section, presented the Guest Speaker, Dr. Howard L. Stier, Head of State Department of Markets, **University of Maryland,** who spoke on the subject "Improvement of Engineering Education through Faculty Evaluation Polls." Dr. Stier discussed features of what was considered a successful faculty evaluation poll conducted in the College of Agriculture at the University of Maryland and participated in by faculty, students and alumni. A very interesting and enthusiastic discussion period followed.

Henry H. Armsby, Vice-President of ASEE and Chairman of the ASEE Committee on Sections, brought greetings from the Executive Board and gave a brief cross-section of the current activities of the Board and the Section's Committee pointing toward the Annual Meeting of the Society at Michigan State College in June.

Unclassified Subject Matter in Nuclear Science and Engineering*

By M. D. PETERSON
Head, Department of Chemistry, Vanderbilt University

The fundamentals of reactor theory, involving the emission, diffusion and absorption of neutrons in various materials, are declassifiable and have been made widely available in books, journals, and Atomic Energy Commission declassified documents. While the best values of certain important nuclear constants are not disclosed, ranges or approximate values adequate for instructional purposes, but not for reactor design, are given. Thus, no school need suffer from lack of materials for teaching the basic nuclear physics. Similarly, fundamental chemistry, biology and health-protection information is declassified and readily available. Also, many of the advancements in nuclear engineering that might be of use in the laboratory or industrial practice of the country have been declassified, although, of course, integrated engineering information on the actual design and construction of reactors themselves, even small ones, remains secret.

Yet the proportion of declassifiable engineering information published is small indeed compared to that in the fundamental sciences. It is unfortunate, but true, that there has not been the incentive for engineers to write up their work for declassification that exists among the research scientists. In general, engineers within the A.E.C.'s installations and those of its contractors carry over the tendency of engineers in outside industries to keep new engineering knowledge and know-how within the confines of their own organization. And also, as in other industries, the engineers within the classified projects are very often under great pressure to meet deadlines and completion dates and cannot find time to prepare papers for publication. In this field, engineering reputations have been based on processes developed and units built, not on declassified publications.

Novel Features of Nuclear Engineering

In the atomic energy business, too, a few very competent engineers with adequate backgrounds in the fundamental sciences and special skills associated with their projects—that is, nuclear engineers—can lead many men trained only in ordinary engineering lines, yet there is still a very real shortage of nuclear engineers and of places to train them for this rapidly expanding business.

Nuclear Engineering involves many new features. Design and development engineers for piles and some processing plants must show great ingenuity and judgment in the choice of remote control equipment. Piles and "hot" Chemical processes must be operated, serviced and repaired ever afterward remotely through shielding many feet thick. An ordinarily routine engineering operation may become very difficult or be handled very differently under such conditions. The development of high-temperature power piles will also require entirely new

* Presented before the Southeastern Section, ASEE, August 28–30, 1950.

materials of construction, as the usual ones generally absorb neutrons too readily or may be damaged by radiation or corrosion. Very little has been declassified in such lines, since they apply primarily to the secret field of reactor technology, but also because there has not yet been much of the necessary knowledge developed, even of the declassifiable fundamental engineering nature that must precede technological use. The materials problems are so severe that the Commission is rushing to construct a Materials Testing Reactor at Arco to assist in their solution.

You will recall that the critical amount of enriched uranium 235 that can be made to undergo chain reaction can be smaller than 200 lbs., or smaller in size than a volley ball. Compactness for mobile nuclear power plants, and high neutron flux densities for experimental piles, and economy in many cases, all create a trend toward high power densities for reactors. The problem of heat removal from the fuel units becomes then a limiting factor, and dependable operation with heat fluxes far beyond those in present engineering practice is required. A relatively extensive heat transfer program is underway, at a number of places within and outside of the Commission's installations, and valuable additions to basic knowledge in this field are being obtained and declassified.

With increasing power density and neutron flux in reactors, the control problem also becomes more severe. For maximum safety and ease in start-up and power changes, one would like monitoring and control instruments that indicate and operate continuously, reliably, and very rapidly over the whole range of neutron flux up to greater than 10^{12} neutrons per square centimeter per second—a million milion-fold range. Instrumentation and control are also fields in which relatively extensive declassified material is available for instructional purposes and for use in other industries, and in which great advances are being made.

Chemical and Metallurgical Processes

There is also activity in chemical and metallurgical processing of special materials that must accompany any pile operations. Much of the fundamental chemistry and metallurgy of the heaviest elements (number 90 and above) has been declassified, but the technology of these materials remains a secret.

Only a small portion of the fuel in a reactor is used up before it must be discharged and re-purified, to remove the fission products which have formed in it and to recover the unused fuel for reuse. Also, any efficient pile will contain thorium 232 or uranium 238 so arranged as to absorb the extra neutrons and "breed" more fissionable fuel, uranium 233 or plutonium 239, respectively. The fission products in all of these materials make them extremely radioactive, so that remotely controlled chemical separation plants must be operated in conjunction with the piles. Also, many of the radioactive fission products themselves are separated and purified for medical and research uses, and many other materials are irradiated in the reactors to make new radioactive isotopes. These operations have led to whole new fields in "hot" chemistry and chemical engineering, in which nearly all of the separation and purification processes used in ordinary practice have been adapted for remote control operations, often in very specialized small-scale equipment made of rare materials, and often modified to give yields and purities far beyond those obtained in ordinary use. Much of this fundamental information has been declassified, but these is much more that is declassifiable and of interest to industry and educational institutions that has not yet appeared.

While I have not even mentioned many of the branches of nuclear engineering, I hope this gives you some feeling for its various problems, the very small start that has been made in this big, new field, and the range of unclassified information about it that is available for your use.

The various sources of information referred to by Dr. Roth are accessible to you all. The most complete group is the Atomic Energy Commission's declassified document series, called AECD's, consisting of a few thousand documents covering all subjects at random, but for which good indices and abstracts are prepared.

However, even the current AECD's often cover work several years old, and there is available within the Commission's installations, such as those at Oak Ridge, far more declassifiable information than has yet been released. Much of this will be of great help to you, but can only be obtained if you seek it out and expedite its declassification yourself. At least one person from each of your engineering departments should become cleared and should participate in the Commission's work at Oak Ridge for at least three months through The Oak Ridge Institute program Dr. Pollard described. Your staff member will then know what information is available and how to get it declassified. Until you can get this familiarity with the Commission's work within your own staff, it would be well for any of you that are interested to discuss the declassified material in your specialty or field of interest with one of the scientists or engineers in that field at Oak Ridge. This can be arranged through Dr. Poor of the Institute and Dr. Roth.

In these ways you may assist the declassification program in one of its aims, to release "information which is of particular value for teaching the basic theoretical principles of reactors and for describing the use of these reactors as tools for scientific research," speed up your programs for education and fundamental research in nuclear science and engineering, and thereby aid the Commission in carrying out its important work.

College Notes

Robert F. Mehl, Director of the Metals Research Laboratory and Head of the Department of Metallurgical Engineering at **Carnegie Institute of Technology**, has been named Chairman of the Metallurgical Advisory Board of the National Research Council.

Applications will be received until March 1, 1951, by the **Oak Ridge School of Reactor Technology** for enrollment in the 1951–52 session, which begins September 10, 1951. This School was established at the Oak Ridge National Laboratory in March of 1950 under sponsorship of the U. S. Atomic Energy Commission for the purpose of training engineers and scientists in the field of reactor theory and technology. A limited number of recent college graduates in chemistry, engineering, metallurgy, or physics will be accepted in the status of student-employees of the Laboratory. Other trainees, sponsored by government agencies and industrial organizations, remain on the payrolls of their home companies. Further information and application forms may be obtained from the Oak Ridge School of Reactor Technology, Post Office Box P, Oak Ridge, Tennessee.

The Undergraduate Nuclear Engineering Curriculum at North Carolina State College*

By CLIFFORD K. BECK
Head, Department of Physics, North Carolina State College

A course of study in Nuclear Engineering has been instituted at North Carolina State College. The School of Engineering of State College, in recognition of the vital role that nuclear phenomena and processes now have and increasingly will have in our society, and in discharging their responsibility to the students of the State and Nation in offering training opportunities in important engineering fields, has undertaken the task of providing a training program in this new field. The curriculum in Nuclear Engineering was organized under the direction of the Physics Department which is a member department in the School of Engineering and currently most of the specialized courses relating to the new curriculum are offered by this department. Many other departments, however, in the School of Engineering and in other divisions of the college are actively participating in the instructional program.

The program at present comprises a full undergraduate curriculum, and, also a course of study leading to the Master's Degree in Nuclear Engineering. A doctorate program is being planned, and should be completed by the time students now in lower curricula are ready for it.

Factors Influencing Decision

Several factors influenced the decision to begin this training program at N. C. State College. Among others were:

A large demand for this type of training: Our applicants come not only from (a) inexperienced students now in school and (b) from members of the armed forces, but a surprising number come from (c) experienced and generally successful persons already on Nuclear Energy projects who wish to broaden the base of their training and (d) from engineers in other fields who wish to transfer to nuclear projects. The total number of applicants is much larger than can be accepted. This broad interest became apparent quite some time before the decision was made to organize the curriculum at State College.

It is virtually a certainty that the present high demand for men with sound basic training in both engineering and nuclear technology will not decrease, but probably will increase. It is true, of course, that a tremendous industrial future for nuclear engineering is contingent on a demonstration of practical and economical power generation from nuclear sources. The demonstration certainly will be attempted, even though it will probably require 5 to 10 more years for the success or failure of the effort to be clearly conceded. The eventual success of power generation on a practical basis probably will be achieved. In the intervening years, however, the manpower total of 70,000 or so now directly engaged in one way or another in our nuclear engineering program will not decrease, even

* Presented before the Southeastern Section, ASEE, August 28–30, 1950.

though military activities, now sharply increasing, had remained constant.

Almost every major installation under the direction of the Atomic Energy Commission is actively searching for additional men with engineering experience. Beyond this, there is apparently a rapidly increasing interest in certain industries, and in industrial and other research laboratories for men with basic nuclear engineering training.

The organized educational institutions of the country can provide basic training more efficiently than any other group. Specialized training and company "know how" must be given almost any new industrial employee, whether he be an electrical or chemical engineer or a bookkeeper. But no company, no matter how large, attempts to provide routine basic training which the employee can readily obtain in established schools. Yet in Nuclear Engineering, the Atomic Energy program has been forced to provide this basic training, as needed, since no schools were equipped to do the job. Indeed, much of the essential information involved in this training could not at first be divulged to the schools. Such is no longer the case, and, in the interests of overall economy and efficiency, the established educational institutions should assume their rightful responsibility.

In addition to training of students, participation of colleges and universities in this program will provide another service which is the traditional contribution of alert professors; namely, the organization, assimilation, and presentation of available information in this new field in coordinated textbook form most suitable for reference and instructional use.

North Carolina State College was particular well suited to undertake this effort in Nuclear Engineering training. The N. C. State College Physics Department has customarily placed heavy emphasis on engineering and applied physics and, being a member of the Engineering Division, is very closely coordinoted with the other 10 engineering departments in the Division. Several of these departments, e.g., chemical, electrical, mechanical engineering, etc., are particularly strong and well-staffed. Hence, there exists for the prospective student ample opportunity for developing a strong foundation and specialization in some orthodox engineering branch, in supplementation of his nuclear technology training.

The administration of the Divisions of the College offered strong encouragement and support in the proposed Nuclear Engineering activity. As the program was being considered, the Physics Department was planning to add several new staff members. When the decision to offer Nuclear Engineering was made, therefore, new staff members were selected who would most effectively strengthen the program.

Definition of Nuclear Engineering

Having decided to initiate a training program in Nuclear Engineering, there remained the difficult tasks of defining nuclear engineering, determining the areas included, deciding how best to teach the techniques involved, and arranging a proper balance with other items necessary in an undergraduate curriculum.

A Nuclear Engineer is defined as one who engages in some activity involving or relating to nuclear processes, and in that activity is able to understand the problems involved and to exert sensible efforts toward the practical solution of the problems. The range of these activities may be extremely broad. The procurement, purification, and preparation of nuclear fuels, the design, implementation and operation of nuclear reactors, utilization of reactors for producing power or radioactive isotopes, medical, physical and industrial research and applications, are only a few of the possible activities in which a Nuclear Engineer may engage. In many activities he is hardly distinguishable from some other type of engineer or scientist. For examples, in mining uranium he is a metallurgical engineer, in providing instrumentation for a

reactor he is performing as an electronic engineer, and in the study of aircraft propulsion by nuclear power he approximates an aeronautical engineer. Yet in all these activities, the nuclear engineer must have not only the usual technology relevant to the particular processes, but also the added ability to recognize, understand and cope with the nuclear phenomena involved.

A Nuclear Engineer therefore must possess the usual engineering requisites, abilities, and attitudes and, in addition thereto have the added abil'ty to cope with nuclear processes which he may encounter.

To be quite explicit. at least 80%, and possibly almost 90%, of the training of a Nuclear Engineer should be basic, orthodox engineering training, with the usual specialization in some standard engineering branch. The remaining 10% or 20% of a Nuclear Engineer's training, though relatively small, is very essential. It consists (1) of an intimate, practical, workable knowledge of nuclear processes and techniques and (2) a subtle difference in philosophy in approaching problems in this new field. This difference in philosophy is born out of the knowledge that remote control, shielding, "zero maintenance," "surgical cleanliness," trace impurities, radiation damage, and "health physics" are primary factors which must precede, though not eliminate or invalidate, the usual engineering considerations in approaching problems to be solved.

The wide scope of activities practiced by Nuclear Engineers may be grouped into two large divisions and a few minor ones. The first major division relates to all types of processes in which the intrinsic characteristic of radioactivity itself is the factor of principal importance. Tracer technology, radiochemistry, and industrial applications of radioactivity in general characterize this type of process. Note here, as in many other similar situations, that much applied engineering practice is involved, though a particular project may be a "pure" research undertaking.

The second major division involves processes which utilize radioactivity and nuclear reactions as a means of producing other processes of primary interest. Nuclear reactors, used as means of producing radioactive isotopes, useful power, and beams of radiation for research purposes, and all the technology relevant thereto, comprise the chief part of this division of Nuclear Engineering.

General Fields Within Nuclear Engineering

The general fields of nuclear engineering include:

1. Tracer Technology
   a. Chemical Processes
   b. Bio-medical Tagged Atom Applications
   c. Indutrial Uses of Radioactive Isotopes
2 Reactor Technology
   a. Research Reactors
   b. Isotope Production
   c. Power Generation
3. Miscellaneous
   a. Biophysical Application and Medical Therapy.
   b. Chemical Effects of Radiation
   c. Nuclear Physics
   d. Chemical Engineering: Waste Disposal, etc.

From the foregoing, the undergraduate nuclear engineering curriculum must satisfy two criteria; and there is a third, as yet unmentioned:

1. It must provide basic training in nuclear technology at least broad enough to include essential information in both Radioactivity and Reactor Processes.

2. It must provide adequate training in the essentials of orthodox engineering, with some degree of specialization in a chosen field.

3. There must be included a sufficient amount of cultural, educational and historical subject matter to produce at graduation as well-rounded a citizen as possible.

Curricular Content

General Basic. 26% of the curriculum is devoted to the general cultural and educational development of the student. English, history, government, economics, social studies, physical education, etc., are included in this important group of subjects.

Basic Science. 32% of the curriculum is devoted to the fundamental sciences of mathematics, chemistry, and physics. Inclusion of biology, while not required at present, is strongly recommended as an elective.

Basic Engineering. 14% of the curriculum in this third category contains fundamental engineering courses considered essential to any field of engineering. Most of these courses are above the sophomore level.

Nuclear Technology. 11% of the curriculum is allocated to the seven required courses in this category. Additional courses relating to nuclear processes are available as electives, to meet the needs of those desiring further training along particular lines.

Technical Electives. Twelve quarter courses, or 17% of the curriculum, may be selected in whatever field of secondary interest the student, with the assistance of his adviser, may choose. These elective courses may be used, for example, to develop a sound specialization in some field of engineering, to acquire proficiency in mathematics, or to develop an interest in advanced biology, chemistry, or physics.

Throughout this curriculum, large emphasis is placed on laboratory practice as a means of insuring practical knowledge of the subject matter. Eighteen of the required courses, or an average of one and one half per quarter, have associated laboratory periods

The present offering of undergraduate courses in nuclear technology is shown in Table I. Several departments in addition to Physics are adding staff members who can develop nuclear technology courses with specialization in their particular field, and a few courses are already offered by Botany, Zoology, Chemistry and Chemical Engineering.

The course of study for the Master's program consists essentially of (1) advanced courses in nuclear technology, (2) mathematics, (3) thesis research, and (4) technical electives. Here again, the electives afford opportunity for the student to develop his interest in a chosen field of science or engineering.

TABLE I

NUCLEAR TECHNOLOGY COURSES

	Qt. Hr. Credits
Physics Department	
Modern Physics	3
Nuclear Engineering	3
Nuclear Instrumentation	3
Nuclear Physics	4
Health Physics	3
Radioactive Tracer Techniques	4
Elementary Reactor Theory	3
Chemistry Department	
Micro and Tracer Chemistry	3
Radiochemical Techniques	3
Chemical Engineering Department	
Processing and Disposal of Radioactive Chemicals	3
Zoology Department	
Biological and Chemical Effects of Radiation	3
Botany Department	
Medical and Biological Applications of Tracers	3

Subject matter for a few of the courses is available in fairly well organized textbooks already published. These texts will be supplemented by material from declassified documents and articles in the current literature. For other courses, e.g. health physics, there is no satisfactory published text material. There is available, however, plenty of information, in fact all essential information, though unorganized and uncoordinated, to form the basis of quite thorough and complete courses. In these cases the instructor must assemble and organize the material and guide the students in their usage of heterogenous sources of information to a larger extent that would be necessary in orthdox courses. This situa-

tion may perhaps afford incidental training of considerable value, since these courses occur toward the end of the undergraduate career when the student should have sufficient maturity to profit by this type of instruction.

This new training program in Nuclear Engineering will be launched in September of this year. The induction of the sixty accepted student candidates, and the arrival on the campus of most of the staff members who will teach these courses, will coincide with the initial offering of this proposed sequence of courses. As students, faculty and courses begin to mix, we are certain to find many changes and adjustments in the curriculum necessary. Our hope is that we may be able to so adjust and adapt the training program that out of it will come men with sound balance as citizens and sound judgment as engineers. We hope they will have a thorough technical training, practically adaptable to the tasks they will find to do. We hope that they will in some measure help us achieve those vast potential blessings inherent in atomic and nuclear processes.

Summer School
Humanistic Social Division
June 21-23, 1951

The Humanistic-Social Division of the ASEE is now making plans for its summer school to be held at Michigan State College in June immediately preceding the regular meetings of the Society. The summer school will be held June 21, 22, and 23rd, and the Divisional meetings of the regular session will be on June 25 and 26. Anyone interested, therefore, can attend both the summer session and the regular Division meetings in a period of six days.

The past two summer schools have been devoted to consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering. All of those who have attended have felt that this interchange of ideas and discussion of common problems has been well worth while, and it is hoped that this year's session will be as valuable as the past two have been.

All members of the Society are cordially invited to attend any or all of the summer school sessions and to participate in the discussions. Anyone who is interested in attending or who has a problem he would like to present is urged to write to Dr. John W. Shirley, North Carolina State College, Raleigh, North Carolina. Further information will be published in the JOURNAL as soon as it is available.

Structural Engineering as a Profession*

By OLIVER G. JULIAN
Chief Structural Engineer, Jackson & Moreland, Consulting Engineers, Boston, Mass.

If some of the statements I am about to make sound dogmatic and categorical, I apologize in advance. Your time and my patience do not permit the inclusion of numerous qualifying clauses as expressions of doubt. As a matter of fact, except for high taxes and perhaps Decartes' *Cogito ergo sum*, I am sure of nothing.

Reading of the history of structural engineering since Euler's time indicates strongly that it is truly a learned profession, demanding a rigorous and liberal educational preparation. New fields, such as relaxation methods, welding and rheology (including soil mechanics), to mention but three of many developed within the span of my memory, show that it is imperative that such educational preparation be continuous throughout one's professional life.

The Culture of an Engineer

Engineering courses leading to a degree might well be preceded by courses in liberal arts, general science and the humanities, at college level, somewhat comparable to premedical courses. Such courses should include:

1) Language, especially the art of using correct, clear and concise English and also including freehand and mechanical drawing. Drawing is a method of conveying ideas and, therefore, can properly be included under the heading language.

2) Logic, the art and science of correct reasoning, including mathematics which can be defined in two words as symbolic logic.

3) Physics, including chemistry and other allied branches of science.

4) Economics, including the mathematics of finance and the application of such fundamental laws as that of supply and demand.

5) General culture. It will be recalled that the mathematician and philosopher A. N. Whitehead said "Culture is activity of thought and receptiveness to beauty and human feeling." Accepting this as a definition, culture can be said to include politics—the relation of human beings to one another. The term "receptiveness to beauty" includes appreciation of an elegant piece of logic and the orderly and efficient planning of work, as well as aesthetics as applied to architecture and the fine arts. Activity of thought is surely a prerequisite of all professional people.

Looking back over my own experience and having in mind my observation of others, I now (forty years after graduation) believe that time spent on such study during formative years will later pay a structural (or other) engineer large dividends. However, the idea may be difficult to sell to impetuous and impatient youth. The youngsters are all too anxious to go to work on the superstructure before building an adequate foundation. It is the duty and prerogative of their teachers and leaders (in and out of school) to curb the students' natural desire to climb the heights of special-

* Presented at the meeting of the New England Section of the American Society for Engineering Education at the University of New Hampshire, October 14, 1950.

ized knowledge more rapidly than they can build a sound structure of general understanding beneath them.

Technical Competence

Having acquired a good foundation in the five categories mentioned above, the acquisition of competence in specialized fields required of structural engineers, such as:

1) Applied mechanics, including kinetics, statics, elasticity, rheology and hydraulics;
2) Metallurgy, soil, concrete, and other technologies pertaining to the properties of materials;
3) The theory of framed structures;
4) The ability to handle men;
5) The efficient handling of monies;

should be a comparatively simple matter, provided the student has a natural aptitude for engineering and is willing to apply himself diligently over a period of years.

A parrot can be trained to recite mathematical formulae, but that won't make him a mathematician—one who creates new methods in mathematics. Likewise, a young man can be trained in structural traditions, codes and building regulations, he can be further trained to prepare design drawings, copy or rearrange specifications, substitute numbers in formulae, and operate a slide rule with dexterity; all this without exercising real thought and without acquiring the educational background he should have as a professional structural engineer. To qualify as such, he should be thoroughly grounded in the basic sciences and the humanities and be able to think for himself. He should be able to reason out problems from bare fundamentals. There is a vast difference between training and education. In short, he should be so educated that he can readily acquire competence in fields which were perhaps unknown, or at least undeveloped, during the time of his formal education and in which he therefore could not be specifically trained at that time; furthermore, he should be prepared to show that the product of his work is practical, stable, and economic. A structural craftsman such as a draftsman or laboratory assistant can be trained. A structural engineer must also be educated. A craftsman has a trade, his job is subprofessional; whereas an engineer has a profession.

Before acquiring status as a structural engineer, the new graduate must serve some time as a subprofessional in a design office and as a surveyor or inspector on construction work. Under language, I mentioned drawing as part of an engineer's fundamental training. I wish to emphasize especially the importance of every embryo structural engineer being a competent draftsman when he steps out of college. This because he will probably start his career at a drafting table, and his advancement will depend largely on his ability to produce accurate and workmanlike drawings in competition with men from trade schools who have had the benefit of considerable training in the technique of drafting. Ordinarily, the college trained engineer soon outdistances his competitor from the trade school, but to start he is all left thumbs as a draftsman. This, however, is not true of the graduate architect. In this connection, the engineering schools might well take a tip from the schools of architecture. The ability to draw is as essential to the young engineer as it is to the young architect, or as the ability to apply a bandage is to a doctor. It appears essential that all graduate engineers leave their schools technically equipped at least to begin their profession and earn a living wage. Such competence includes, among other things, the ability to produce accurate design drawings, in a workmanlike and efficient manner.

Further regarding language, the ability to speak and write something approaching the King's English, to organize one's thoughts and express them cogently, clearly, and concisely is obviously a great advantage to anyone. It is especialy important for the engineer who is called on

to prepare specifications, write reports and "sell" ideas. I have repeatedly noted that the engineer who has the ability of skillfully using English advances at a much more rapid rate than his less cultured brother of perhaps greater purely technical ability. Also, the ability to think through and express mathematical formulae in words (as well as in symbols) often leads to a better understanding. For example, the words—"The curvature due to flexure varies directly as the applied moment and inversely as the flexual rigidity"—at once reveal that this fundamental law of flexure is contained in Ohm's law in generalized form —"Effect is directly proportional to effort and inversely proportional to impedance"—and give one a common sense view of the law of flexure. Such common sense views are all too often neglected; we, at times, allow ourselves to become so involved in, and perhaps hypnotized by, purely formal processes that we lose sight of the over-all picture. This may be the result of cramming too much rich mental food without allowing adequate time for digestion.

Mathematics and Common Sense

I thoroughly agree with Professor Hardy Cross [1] that "Mathematics, at least as generally (ordinarily) used, is a mechanical brain." (A substitute for thought.) However, such a concept ill befits professional men. Cross's own work leaves no doubt that he does not so use mathematics. According to Professor E. T. Bell,[2] "In its most powerful form, deductive reasoning is mathematics." I wonder if, in educating professional men, we should not get away from the idea of using mathematics as a mechanical brain. Is it not practical, more generally, to teach mathematics as a branch of logic (the art and science of correct reasoning) rather than as a substitute for thought? The close examination of definitions and premises, the scrutiny of meaning at all stages of an argument, and the appreciation of range of application are far more essential than purely formal skill in mathematical processes. No matter how involved or elegant the argument, the conclusions (except by accident) can be no better than the basic data. In fact, the more involved the calculations, the more need for an over-all common sense check. We all know that, if the argument leads to contradiction of the basic law of statics or the principle regarding conservation of energy, the conclusion is in error. Such checks should always be applied.

To teach mathematics as a branch of logic probably requires far more time and mental effort by both the teacher and the student than, in general, is presently devoted to this important subject in engineering schools. The requisite time for digestion—thinking things over at one's leisure—is far from negligible. Modern engineering makes such large demands over such a broad and ever-increasing field of what is commonly known as higher mathematics that I believe courses in pure and applied mathematics should extend over the student's entire academic career and that a graduate engineer should continue to study and use these subjects throughout his professional life. What proportion of our graduate engineers can and will use calculus and differential equations or probability? They all should.

Economic Results

All structural engineers of professional status should be capable of thinking in terms of economic results. Owners who employ engineers, being business men, always do. As a matter of fact, a professional engineer is essentially an economist. A structure, be it a bridge, tunnel, dam, power plant, factory or office building, should earn a fair return on the invested capital. The determination of which of several schemes is the

[1] "Technology and Education for Engineers," *The Yale Scientific Magazine*, April 1946.

[2] "Development of Mathematics," 1st edition (1940). McGraw-Hill Book Company, p. 546.

better economic solution and what portion of a given development should be built at a given time in order to produce economic results is as much a part of an engineering problem as is the determination of the structural stability of the work. Such problems require a working knowledge of at least statistics, probability, cost keeping, cost of funds, depreciation, obsolescence, amortization, property taxes, annuities, present worth, and earning power. Of course, considerable uncertainty is inherent in all economic comparisons. Like problems in applied mechanics, the conclusions can be no more accurate than the assumptions and premises on which the argument is based. However, in either case we can use as many sets of reasonable assumptions as are necessary to bracket the range of uncertainty and derive corresponding conclusions on which to judge the relative economics, or safety of the structure. In both cases, unique solutions exist only in over simplified cases which have no counterpart in reality.

In the last analysis the professional engineer, like the business man or other professional, must rely on judgment. Common sense can and should be aided by the application of scientific methods, but it can never be entirely supplanted by such methods.

In the catalogue of subjects pertaining to mathematics of finance given a moment ago I mentioned statistics and probability. In his recent prize winning paper entitled "Safety of Structures" Professor A. M. Freudenthal [3] has demonstrated that these subjects are also most important in estimating the relative safety of structures. Surely an owner has the right to ask his engineer the following listed questions regarding a structure designed or reviewed by that engineer:

(1) What superimposed overload will the structure probably withstand without causing collapses?
(2) What superimposed overload will it probably withstand without impairing its usefulness?
(3) What is the probability of failure?
(4) What is the probability of its becoming unserviceable?
(5) What is its probable useful life?

I wonder how many practicing profes sional engineers can give cogent and concise answers to these questions within a range of reasonable accuracy. We are only now beginning to develop rational methods for:

(1) Estimating the probable resistance of a structure.
(2) Estimating the probable loadings to which a structure will be subjected.
(3) Correlating the resistance and the loading so as to insure reasonable serviceability and safety without sacrificing economy.

Here is a large field for development in structural engineering.

I have sometimes heard it said that a member of the profession who has become largely concerned with executive and managerial duties, rather than with purely technical details, such as strength and deflections, is no longer practicing engineering. One might as well say that a general engaged is directing troops is no longer a soldier. Such jobs require a broad viewpoint, including understanding of the relation of human beings to one another—humane engineering—understanding which is acquired largely unconsciously through experience, study of the humanities and cogitation. It is largely the ability to handle executive, managerial, and general business matters in addition to having technical competence which distinguishes the professional man from the technician and craftsman.

In conclusion—traits of character, such as following the Golden Rule, which in itself comprises a code of ethics, the willingness to think and work hard, without regard to hours, are prime requisites of any professional man.

[3] *Transactions ASCE*, Vol. 112 (1947), p. 125 *et seq.*

Metallurgy in the Mechanical Engineering Curriculum*

By RICHARD F. EISENBERG
Assistant Professor of Metallurgy, University of Rochester

Next to the metallurgist, the mechanical engineer probably has the greatest need for knowledge of metals. The need for this knowledge is evident, and in recent years more and more emphasis has been attached to its importance. Industrialists and educators alike are in agreement that mechanical engineers need a strong background in metallurgy. But are we doing the most effective job in our engineering colleges? Are we giving our engineers enough metallurgy, and is it of such a nature that it will equip them to do the best work for themselves as well as for their employers?

It is true that all mechanical engineering curricula contain some course work in metallurgy. In general, however, the nature and extent of the metallurgy requirement is inadequate. In most curricula the metallurgical instruction is contained in a three hour lecture course in "Engineering Materials," which is meant to cover such topics as: cement, concrete, fuels, plastics, wood, as well as the entire field of metallurgy. The best that can be expected in such a diversified course is a general and superficial treatment of each of the topics considered. There is little possibility, in this type of course, of giving the student an understanding of the basic nature of the materials. Consider only the field of metallurgy. It is, in itself, a widely diversified field. Generally, it is divided into two branches: chemical metallurgy, which involves the extraction of metals from their ores; and physical metallurgy, which involves that vast field of the adaptation of metals to use. Each of the branches can then, of course, be subdivided into ferrous and non-ferrous metallurgy. It is the branch called physical metallurgy which is of the greatest concern to the mechanical engineers. If the three hour course in engineering materials were devoted to this topic alone, it would be inadequate.

The three hour course would be inadequate because metallurgy as a science is relatively new, and since it got a late start there is still considerable basic knowledge that must yet be thoroughly investigated. Great progress has been made in metallurgical thinking in the past 50 years. The theoretical thinking as well as the practical thinking has expanded greatly, and with the many basic problems yet unsolved there is every reason to believe that this development is going to continue at a rapid rate. Much of the knowledge at hand at the present time is in the category of an art rather than of a science. If the mechanical engineer is to be well versed in his most important tool—metals—then he must be given training that will equip him to keep abreast of the changes as knowledge leaves the category of an art and becomes a science. The teaching of strength of materials, physical and mechanical properties, heat treatment, composition of alloys and good handbook technique will not accomplish this purpose. A basic

* Presented at the Annual Meeting of Upper New York State Section of ASEE, The University of Buffalo, October 14, 1950.

understanding of metals is required. A good basic course will give the student the understanding of the behavior of metals, which is necessary to prepare him for further learning. In addition, this basic knowledge will give greater meaning to his study of heat treatments, mechanical working, mechanical and physical properties and composition of alloys.

It is believed that this training can be satisfactorily accomplished in two three hour courses, provided the time is devoted solely to the teaching of metallurgy. Instruction would be principally in physical metallurgy; chemical metallurgy need only be touched lightly. The first of these courses would be a lecture course in the "principles of physical metallurgy" covering the following general topics:

Solidification and atomic structure
Crystal properties
Physical properties
Mechanical properties and deformation
Structure of alloys and constitution diagrams
Equilibrium and non-equilibrium reactions in solids.

The treatment of these topics should be strictly basic in nature.

This basic course would be followed by a course in applied physical metallurgy, consisting of two lectures and one laboratory. In this course there should be a "tie-in" of the fundamental knowledge with the practical knowledge, and also certain phases of the basic information should be verified.

It is not expected that such a program can qualify graduate mechanical engineers to compete with graduate metallurgists, but it will give them training that will equip them to face new problems in the field. It will also give them a better understanding of the old problems.

The above programs should be compulsory for every mechanical engineer, and in addition he should be afforded the opportunity to take additional and more advanced courses as his electives. In all courses offered, however, the basic knowledge should always be kept to the front, the practical knowledge will come with experience.

What Are the Problems in the Field of Industrial Engineering?*

By H. RUSSELL BEATTY

Professor and Head of Department of Administrative Engineering, Pratt Institute

The problems encountered by the industrial engineer in practicing his profession may be classified into four groups, namely:

1. Economic
2. Control
3. Technical
4. Human Relations

The economic, control, and technical problems can be solved by combining a thorough knowledge of the principles of industrial engineering with the application of the scientific method to such problems, but the fourth and probably most important group of problems to be met is that associated with the human relations aspects of the position. It is in this latter area that the real art of leadership is required, and those who fail in this respect are limited in their progress. Let us discuss each of these groups of problems in turn.

Economic Problems

The industrial engineer is constantly choosing between alternatives. He must decide whether this process or another should be adopted, this machine or another, this tool or another. These choices are made on the basis of economic considerations. Under the conditions prevailing at a given time, there is one method that will result in the lowest total cost and it is this method that the industrial engineer seeks. He cannot spend more money finding the method than he can save with it, so judgment must be used regarding the amount of investigation warranted by the economic conditions surrounding the problem. In addition to engineering economy principles, and a thorough process knowledge, the industrial engineer needs economic judgment to help him to decide when he has carried his economic analysis to the point where action rather than more analysis is indicated.

The economic problems most frequently faced are:

A. Economic selection of plant and equipment. This includes size as as well as process and equipment planning.
B. Economics of manufacture. This includes methods, tools, labor specifications, limits and tolerances on dimensions, and the like.
C. Economics of materials. This includes determination of manufacturing lot sizes and economic ordering quantities. Inventory turnover studies and the economics associated with materials handling and storage are also included.
D. Depreciation determination. This includes using adequate judgment regarding the long term economic factors involved in spite of the Federal Income Tax handicaps now prevalent.

An industrial engineer should make it a habit to apply engineering economy principles to problems of operation

* Presented at the Annual Meeting of the Industrial Engineering Division, ASEE, at Seattle, Washington, June 18, 1950.

wherever he must choose between two or more alternatives. This practice will act as an aid to his judgment. It will not take the place of good judgment, but will help to make judgment better.

Control Problems

Industrial engineers are continually faced with problems of control. How can a system be set up so that there are rules for recurring situations (policies) and only the exceptions brought to the attention of the executives for action?

Problems of this type are solved by designing systems for control that will result in obtaining the purposes, objectives and goals for which the enterprise was established. Control systems should contain plans for reaching the objectives. These plans are released by issuing orders. The actual results are then compared with those planned by continually observing, inspecting, and recording progress.

The following are some of the control problems faced by industrial engineers:

A. Production Control
B. Inventory Control
C. Quality Control
D. Cost Control through:
   1. Budgets
   2. Work Measurement
   3. Materials Control
   4. Cost Accounting
E. Wage and Salary Controls

The establishment of standards of performance and the measurement of the actual performance of each division of the enterprise against the established standards are important parts of the industrial engineer's duties.

Technical Problems

Industrial engineers meet a variety of technical problems which require engineering knowledge for their solution. Sometimes the problems are simple, such as the air conditioning of an instrument assembly area, but frequently they are very complex including the complete layout of plant and processes for the economic manufacture of one or more products.

A plant is a big machine through which raw materials pass to be converted into finished products through the efforts of men and mechanization. The design of plants of this type including the plant and process layout and construction, are technical problems requiring the best engineering talents procurable.

The following are some of the technical problems faced by industrial engineers:

A. Plant and Process Design and Construction
B. Methods Analysis and Specification
C. Tool Engineering
D. Work Simplification
E. Time Study
F. Maintenance Engineering including buildings, machinery and equipment, utilities, power plant
G. Safety Engineering

Human Relations Problems

Industrial engineering is a staff or advisory function, and those performing this function are often subject to considerable criticism from those in line positions, and vice versa. Frequently, where the human relations problems have been mishandled, there is antagonism between the industrial engineers and other members of the organization. The reasons for this are apparent, for industrial engineers are continually upsetting the status quo, and this causes dissension unless it is handled with due regard to the feelings of those affected. Therefore human relations problems are among the most important with which the industrial engineer must deal. These problems are caused by the following:

1. Industrial engineers are individuals who change things. They change methods, plant layouts, standards of performance, systems, standard procedures, etc. They are continually on the lookout for new and improved ways of doing things. But each time a change is made, the habits of people are changed. People do

not like to change their habits, to learn new things, particularly if the changes are sudden. So industrial engineers, to be successful, must learn to adjust the workers and supervisors to the changes about to take place by frequently discussing the changes with those affected. This conditioning helps the individuals to adjust to the new problems which they must face, and when the changes are actually made, there is less friction.

Industrial engineers "short circuit" the line and communicate weaknesses of individual members of the line up the ladder to top management. They disturb the filtering process by which those things which are not complimentary are removed from the communicatións as they are sent up the ladder. The boss gets only the things he likes to hear from his subordinates, but the staff reports disturbing things up the line. Supervisors do not like this observation of their performance and often are antagonistic to industrial engineers for this reason. To avoid this, industrial engineers frequently point out the errors or omissions to the line and refrain from reporting it up the line until it is apparent that the line cannot get the desired results. Often the real difficulty is caused by the failure of the industrial engineer to win the cooperation of the line by his intellectual and technical leadership ability.

Industrial engineers establish measures of performance, and set up control devices by which results that deviate from the standards of performance are reported up the line. This constant checking on performance often causes antagonism in spite of the fact that once installed it is impersonal and factual. Those affected remember conditions as they were before the controls were established and blame those responsible for their installation for the increased supervision that results.

The industrial engineer must approach the Human Relations Problem with a good deal of understanding of his fellow worker and his reactions, and continually strive to help him to adjust. He must be patient and understanding while men are making adjustments. He must help to train them in the new methods and explain the need for new points of view regarding controls, supervision, and the like. If he is to be successful, he must follow the Golden Rule of doing unto others as he would have them do unto him. Only in this way will be accomplish the desired results, and maintain the good will of his industrial associates.

To sum up: The industrial engineer faces four classes of problems as follows:

1. Economic
2. Control
3. Technical
4. Human Relations

It is this last one that makes his work so different from that of the mechanical engineer. The design of a machine calls for solution of technical, economic, and control problems, but the number of human relations problems involved is in the minority. The industrial engineer, in designing a plant and its organization which is composed of hundreds of human beings, must devote much more of his time to the solution of human relations problems.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 15, 1951 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President ....

....

For Vice-President ....
(In Charge of General and Regional Activities—two years)

....

For Treasurer ....

....

Signed ....

Title ....

Institution ....

Date ....

The Employment Opportunities in Small Industries for Engineers*

By A. R. HELLWARTH

Assistant to the Employment Manager, Detroit Edison Company, Detroit, Michigan

When the Relations with Industry Division had its first meeting for the 1949–50 school year, everyone was concerned about the prospects for jobs for the 50,000 graduates during that year. The Division, along with many other engineers and educators, believed that a good market for some of the 1950 graduates was in the many small industries in our country. The Division prepared a brochure on the subject entitled "Engineers Offer New Frontiers." 25,000 copies were distributed by our engineering colleges to the companies in their respective areas.

Reports at the Seattle meeting indicated the outlook had improved—a number of schools reporting that 60 to 80 per cent of their students had jobs before graduation. Then the entire employment situation was changed by the new international developments. By late fall, any graduate who wanted to go to work had a job and the talk switched abruptly to a possible shortage in the near future, in view of the alarmingly small Freshman, Sophomore, and Junior enrollments.

Undoubtedly many of the recent graduates are at work in small industries around the country and as they prove their value to their employers, the demand for others will increase. The possibilities of developing further this field of employment are well presented in Dean C. J. Freund's address on "Partnership With Industry" (*A.S.E.E. Journal*, May, 1949).

What is Small Industry?

An understanding of what is meant by "small industry" might keep us all thinking of the same or similar situations. Let us keep in mind any manufacturing or service industry where the product or service is of such a nature that the application of engineering principles or the use of the engineering method in solving the day's problems would bring benefits to the business.

As to size, it does not appear that an arbitrary maximum can be established based on dollars invested in plant or gross sales, or on the number of employes. Some small industries, by their very nature, are well stocked with engineers.

Generally speaking, the industries being considered will vary in size from those with a few mechanics or technicians operating from a garage or basement at home to one with one hundred employes and a million or so dollars of sales annually. Presumably, when they get bigger than that, it has been through the benefits of engineering services.

The Potential Employers

The U. S. Department of Commerce statistics show that in 1948 there were over 300,000 manufacturing enterprises with less than 100 employes. It has been estimated that 200,000 do not have a trained and experienced engineer. It might be said that this represents that

* Presented before the ECAC at the Annual Meeting of the ASEE, Seattle, Washington, June 19–23, 1950.

many opportunities. Not all small industries, of course, can be convinced that they would benefit from employing one, but some young men with initiative and drive can sell themselves to some of these prospective employers. Several localized surveys verify that the market is there.

The opportunities in small manufacturing industries and engineering service organizations are quite obvious. Small public utilities of all kinds have opportunities similar in nature; so do mining, oil producing and refining companies, and processers of chemical products. Ownership and operation of large buildings such as offices, stores, hotels, schools, hospitals and large governmental institutions call for considerable engineering skill and services.

In addition, there must be countless opportunities in non-technical businesses, large or small, for employes with the kind of training that the engineering graduate receives. Some of these are the food, clothing, housing, transportation, printing, newspaper, and merchandising businesses. In any non-technical business there are somewhere in its operation some technical problems. Any business operating a fleet of cars or trucks needs a mechanical engineer, for example. In addition, an engineer with the right personal qualification is likely to advance into any phase of the management in such a business.

Closer scrutiny of one's home town may disclose situations of these types and others that offer opportunities for engineers that have formerly been passed up as something less than suitable for an engineer. Engineering colleges located in those states where there are fewer large industrial centers are recognizing this more and more. Dean J. H. Lampe, North Carolina State College, says in his paper on "Engineering Colleges and Industry" (*A.S.E.E. Journal,* March, 1950), "I believe that the Society has its greatest challenge and its best opportunity to serve the future young engineers by expanding its work with small industries."

What to Know About Small Industries

Some of the characteristics and factors for the student to take into account while considering employment with small industries are:

1. There are many types of industries and a large number of individual enterprises in each type. Each graduate has the opportunity to consider a prospective employer with the kind of business that would be in line with his interests and specialized education.

2. Small industries are located in every state and in small towns as well as large cities. The graduate may find more attractive situations from the standpoint of geography and a choice of living conditions than if he seeks employment with large industries. He may find opportunities right at home where friends can be of great help in the process of getting the job.

3. Many small industries are owned by an individual or several partners, or by relatives. The owners may also actively manage the business. Before employment, the engineer should investigate the ownership and management factors and what their influence might be on his future progress.

4. An engineer employed in a small company is likely to accumulate a variety of experiences over a short period of time as compared with a large organization where each employe tends to become highly specialized. He will learn a great deal about labor relations, markets, taxes, accounting and other subjects other than engineering. He will find himself in a highly competitive situation. If properly suited, he may experience rapid advancement in both responsibilities and earnings.

5. When the small employer hires a young engineer, he will expect immediate production. He isn't hiring for a job that he sees ahead ten years. Training programs and opportunities to associate daily with members of one's profession may be non-existent. If the young engineer doesn't fill the immediate needs of

the business, out he goes. The small employer may therefore prefer to hire an engineer with experience. Such experience may be attained through a few years with some related large industry. In general, probabilities of a person transferring to advantage will decrease with length of service in the large company. He either becomes a specialist there or acquires a feeling of security that he values highly.

6. Many small companies may not have plans for developing their own top executive staff, but employ people who have proved their abilities in other companies. This may at first seem to restrict one's opportunities. Actually it provides opportunities for advancement in other small companies beyond those the engineer has in his present employment.

7. Small companies may not have as well established policies and rules applying to employe and labor relations as are required in the management of a business with thousands of employes. For an example, there may be no pay for overtime work nor employe benefit plans providing insurances and pension. The relatively higher degree of security in large companies also appeals to some people, but the kind of engineer who is most likely to succeed anywhere is not deeply concerned about finding a safe job. He will establish his own security.

8. The person who has a desire to own the tools with which he works, or to have his own business some day, will find greater opportunity in small industries to develop under conditions favorable to that attainment. He may find some of his rewards in part ownership of the business for which he works.

9. While it is important that a prospective employer be in sound financial condition and able to offer good prospects for the future, there are so many factors that influence the success of any industry that it is impossible to take a look into the future. The reserves of such a business are generally low; there must be a steady output. The ability of the engineer to bring new successes to the business may determine its future as well as his own. Keep in mind that there will never be a better time of life for the young man to take the high-odd chances than now. And for the winner, the stakes are larger. If the first position doesn't work, he can then use his experience to better advantage on the next job.

Finding Employment with Small Industries

The graduate must recognize that here is a prospective employer who isn't likely to come to the campus for interviews. Besides, he may never have thought of hiring an engineer or any college graduate. The job of finding the job and selling himself rests largely with the graduate who thinks he has the qualifications for this kind of employment.

The graduate's field of specialization and interests should help in deciding on a type of industry—e.g. plastics, air conditioning, machine tools, television, automotive parts. A good ready knowledge in the field and of the prospective employer's particular business is impressive.

A good source for names of companies and information about them is the trade association for the field selected. A 1949 U. S. Department of Commerce publication entitled "National Associations of the United States" by J. Judkins gives a complete list. (Superintendent of Documents, Washington 25, D. C., $3.50.)

There are aids and sources of information that any library can help supply. Trade magazines carry advertisements by many small companies. Credit and financial rating books often supply helpful information about a company, including number of employes and nature of business. Some good references are:

(1) Sources of Business Information—Edwin T. Coman, Jr. (Prentice-Hall, 1949)
(2) Thomas' Register of American Manufacturers
(3) Poor's or Moody's—for financial information

(4) Central Stations Directory (electric utilities)—McGraw
(5) Local city directories—Polk, the telephone directory
(6) Local engineering societies or Chambers of Commerce
(7) Classified ads in newspapers

While letter writing may be a means of getting in touch with a larger number of prospective employers, it will not generally yield as favorable a result as the interview. The applicant should not write to any employer that he isn't willing to visit at his own expense.

Responsibility of the College and the Profession

The faculty, placement officers, and other members of the profession can be of considerable assistance in the matter of helping the graduate find his place and become properly oriented to employment in small industry. There need be an increased amount of contact and acquaintanceship with the owners and managers of small companies. Dean Freund in his address on Partnership with Industry says: "It is unlikely that the small employer will become interested in college graduates unless he knows an engineering college professor and thinks he is a pretty good sort of person. And the small employer will not know any college professor unless the college professor cultivates his acquaintance."

Only the right men who will succeed should be recommended for this area of employment. As young engineers succeed, there will develop rapidly a market for more. The reputation of the college and of the profession is also at stake with these employers.

The small employer needs help on how to train and what to expect in the way of progress. The profession need give him some assistance with respect to getting the young engineer off to a good start.

The young engineer who works in a small industry may have little opportunity for contacts during the work day with members of his profession. He should be encouraged to participate in professional Society activities and to take advantage of educational facilities in the community. In small cities, his opportunities for off-the-job activities may be more in service or business organizations and in his church. Proper orientation into the community is just as important as getting a good start on the job.

Conclusion

While it may not be necessary in the next decade to uncover new opportunities for engineers, the importance of this small industry field should not be underestimated by either the college or the graduate. It is a place where the engineer can be of service and many will find opportunity for full professional development and success.

The job-seeker is more likely to find suitable employment in this field if he applies the engineering method. Here is one of life's problems to define, facts to bring together, values to select and conclusions to arrive at, and then actions to plan and to carry out. With the right attitude and a brave spirit, this job of finding the right job can be interesting, educational, and one of life's treasured experiences.

Labor Relations and the Engineer

By ARTHUR STARTZ
Instructor in Humanities, Cooper Union

The art of engineering is concerned with the application of scientific knowledge to bring about greater human happiness through increased or improved production. The study of labor relations, too, is concerned with effecting greater human happiness, through the maintenance or establishment of those institutions and practices which minimize strife and hence foster production. Engineering is concerned with the inanimate aspects of production, the mechanical tools, machinery, power and plant. Labor relations deals with human beings. In our economy, it is concerned with the associations between employees and management. Increasingly, engineers are becoming concerned with the human aspects of production.

To successfully solve the engineering problems of production today, engineers find it necessary to employ scientific principles, not merely "common sense." During the past few decades, social scientists and industrial psychologists have applied scientific analysis to the field of labor relations, with startling results. Many of the "common sense" doctrines which management assumed to be true were discarded. A difficult problem resulted—the retraining of supervisors. Enlightened management groups recognized that pursuit of the old ideas would defeat their own purposes. The complete reorientation of supervisors which was necessitated proved difficult of accomplishment. Industry today looks for men who have some training in the scientific approach to labor relations.

So far, we have approached the subject from the standpoint of management. There is another aspect, important to many engineering graduates who may come to identify themselves as employees rather than management representatives. If the wide disparity between the number of engineering graduates and the number of available jobs returns, it is likely than an increasing percentage of graduates will come to identify themselves as employees. This tendency cannot be ignored.

It is to the credit of the Engineers' Joint Council, representative of the professional societies, that such matters as salary studies have been initiated, indicating an awareness of the changing situation and a dynamic approach to present-day needs. One union of engineers has maintained that college professors are often active recruiters for engineers' unions because of the overly optimistic and fallacious picture they give their classes concerning engineers' employment conditions. More prevalent, it seems to me, is the omission of adequate discussion of this problem. In face of such a statement, perhaps the colleges should reevaluate the curricula. Students should have the opportunity to attend labor relations classes led by qualified instructors. The field of labor relations is a highly specialized one. The labor relations instructor must have had graduate training in this specific field and where possible, some actual experience, and not merely an instructor burdened with another course.

Collective Bargaining

Collective bargaining is the principal institution which the democratic nations

have developed in the field of labor relations. As collective bargaining in the United States progressed, it became necessary for government to step in with regulatory legislation of varying types. These labor laws directly or indirectly affect each of us and there is much disagreement as to what form they should take. The present federal law, the Labor-Management Relations Act of 1947 (Taft-Hartley Act), has been a burning issue in recent elections and will probably continue as a subject for debate during the coming year. It is essential that engineering graduates, who will assume positions of leadership in the community, be in a position to weigh the provisions of our labor laws in an objective and intelligent manner. A group of junior and senior engineering students recently did not display such objectivity or intelligence. When asked their opinions of the Taft-Hartley Act, 90% had very definite opinions. When questioned about its provisions, the majority displayed total or fundamental ignorance.

We have been considering the broader aspects of the import of government in labor relations. Section 9b of the Taft-Hartley Act deals specifically with unionization of professional employees and Section 2 defines the term "professional employee" to include engineers. Surely engineering graduates should be thoroughly familiar with the provisions of a law that deals specifically with them.

Here, then, we may summarize the aims of the labor relations course in an engineering college:

1. The vocational aim—acquiring familiarity with important labor problems and proposals for their handling.
2. The citizenship aim—stimulating interest in and developing objective attitudes toward labor problems, labor disputes, and labor legislation.

In furtherance of the aims just mentioned, it is important that the attitudes of management and union labor toward specific controversial matters in the field of labor relations be examined. It must be emphasized that attitudes of individual unions and individual management representatives may differ from the prevailing feeling. Perhaps, then, we should speak of attitudes of "management-minded" and "union-minded" groups. Cases showing this variation in attitudes should be discussed and the reasons therefor investigated.

Two objectives must be kept in mind: (1) to ascertain what the "labor" and "management" attitudes are, and (2) to determine why these feelings exist. There are two methodologies which will best enable the attainment of these objectives: (1) the case method, (2) guest speakers from the ranks of management and labor. In a two-semester course, both can be used in a complementary way. There is no better way to comprehend these attitudes and the reasons therefor than by discussing cases and by listening to union and management leaders present their views. The lecture method is more likely to result in memorization than in understanding.

At the outset of the course, it is extremely important that the student group and the instructor work out a modus operandi, which will include: defining the problem, obtaining and evaluating data, recognizing insufficiencies of information, arriving at conclusions where possible. However, there is no automatic transfer of the scientific method to labor relations. But unless the scientific method is applied, class sessions will degenerate to debate rather than analysis. Labor and management representatives are not the only ones who have developed attitudes on labor relations matters. Unless the class atmosphere allows a challenge to the preconceived ideas of the group itself, little will be accomplished.

Labor and Management Views

To be more specific, what are some of the conflicting attitudes of "labor-minded" and "management-minded" representatives? It may be well to briefly list a few typical opposing responses.

The Institution	Management Response	Labor Response
Closed shop	Labor monopoly. Undemocratic. Foreign to "American Way."	Strong and effective unionism. No "free-riders," each should share in costs of benefits of unionism. Union security.
Scientific management	Efficiency in production. Lower costs and prices.	Speed-up system. Lower wage rates.
Machinery	Efficiency in production. Lower costs and prices.	Unemployment. Lower wage rates.

If the modus operandi outlined above is followed in studying these attitudes, students will undoubtedly turn to the historical background as one important source of relevant data. A broad knowledge of labor history, studied in a purposeful manner, will prove a valuable asset in understanding attitudes, institutions and trends. A few historical facts will be briefly mentioned, in skeletal form, to illustrate with particular reference to the institutions and attitudes just outlined. The purpose here, of course, is solely to illustrate the importance of relevant historical facts, not to weigh the pros and cons of opposing attitudes. Two examples follow.

(1) The closed shop was an important technique of early trade unions in America, employed by craft unions in the 1790's.

(2) Both scientific management and machinery have resulted in greater productive efficiency, lower costs and higher living planes. This is measurable. On the other hand, historical evidence shows that speed-ups have frequently resulted from time and motion studies and that the unplanned introduction of machinery has created important immediate problems of unemployment.

Historical data are valuable in tracing the origin and development of institutions and attitudes. They are used, too, in redefining the issues, e.g.—labor union opposition to the introduction of machinery being replaced by demands for protection against unemployment when machines are introduced.

It has been said that the study of labor relations is the study of human relations in industry. This does not mean that the labor relations course should concern itself solely with the relations between the individual employee and management. In fact, personnel departments in some of our large industries are still making this error. The fundamental relationship between workers and management today is between union and management representatives, and sometimes between groups of unions and groups of management representatives. Defining the employment relationship is now accomplished through collective bargaining in industries with which engineers are connected, and the individual bargain has yielded to the collective bargain. Union desires often necessarily differ from those of an individual employee. Under such conditions, where management attempts to satisfy the individual demand without recognizing the importance of the union attitude, disruption in the labor-management relationship will be created. The labor relations course in an engineering college is concerned primarily with collective bargaining, the process and the agreement.

Union Objectives

It is essential to study union objectives and tactics. Internal union functioning itself must be examined to get a realistic understanding of the dynamics of collective bargaining. The reverse of this

approach, too, must be applied. In order to understand management's response to the union movement or to a particular union, it is necessary to understand how management looks upon itself, what it considers to be criteria for success, what it considers to be its functions in the economy, what its intense convictions are. The changing concept of management prerogatives, an inevitable result of collective bargaining, is a subject for study by managements, unions, and students of labor relations.

The young college graduate who is thrown into industry with no study of labor relations will have difficulty in understanding many worker reactions. The engineering graduate, who has been steeped in the tradition of efficiency, will experience even greater difficulty. If he has any supervisory function, an understanding of worker reactions is indispensable. It is a common failing of young supervisors to expect routine workers to be much more zealous in their jobs than they actually are. An example may help to clarify this point. Where a merit-demerit system is employed, the supervisor may beamingly inform an employee that he has just recommended that several merits be awarded him. To the young supervisor's amazement, the worker may grumble in reply: "That's fine, but you can't eat them." If this reaction recurs on several occasions, the supervisor should begin to question how meaningful the merit system in this plant is. Why do the employees feel this way? To what degree can merits and demerits be relied upon to secure greater efficiency? Through the case method in the labor relations course, the engineering student will be psychologically predisposed to accept such reactions, in fact to predict them.

One of the important desires of the worker and his union is to obtain as great a degree of job security as possible. Workers who get the feeling that they must make the job last may slow down in combination without a word having been spoken among themselves. In a plant where efficiency has been the sole criterion in layoffs, they may insist on the extreme application of seniority. With no background for understanding, the young engineer will react emotionally and ineffectively in condemning the soldiering and seniority. He can see no reason why he cannot retain an employee who is more efficient than another with greater seniority. Of course, he may react in the opposite way if he himself is laid off in violation of the seniority principle, although it is well-known that there is much less reason for seniority in skilled than in routine work. A labor relations course will provide the background for analysis of specific problems such as these.

We have been considering a few illustrations of course content. It has been mentioned that guest speakers from the ranks of management and labor are extremely valuable in this type of course. Formalized assignments in the various aspects of the course should be supplemented by lectures given by responsible management and labor representatives. It is necessary that the students have background for the particular topic of the day prior to the presentation by the guest speaker. It goes without saying, of course, that the instructor must be well satisfied with the qualifications of the speakers invited, both professional competence and speaking ability. It is desirable that the instructor hear the labor or management representative speak prior to the invitation. Sessions of this type should be as informal as possible, conducted in seminar fashion. Speakers who might be typically invited include personnel directors, directors of training, vice-presidents in charge of labor relations, union officers, union economists, and labor arbitrators.

One final note on outside speakers in connection with another aspect of the course. Increasingly, government is assuming importance in labor-management relations. It is important to know what legislation in this field provides, how it

has been interpreted, and how the agencies which enforce the law function. Representatives of the National Labor Relations Board, State Labor Relations Boards, the Federal Mediation and Conciliation Service, State and City Mediation Commissions, and State Councils Against Discrimination in Employment have much to contribute about the functioning of government in the labor relations field.

It should be apparent that a labor relations course provides an excellent opportunity for integration of various disciplines of learning. Economics, psychology, history, sociology, law, industrial engineering—all have contributed to a basic understanding of employee-management relations. The labor-relations course, given in the senior year preferably, is a fitting bridge between the formalized learning in higher education and the dynamics of relationships which know nothing of artificial departmentalization.

How to Read Freshman Themes*

By JAMES H. PITMAN

Chairman English Department, Newark College of Engineering

Reading themes to the best of one's ability is the greatest service an English teacher can render to his students. If I have not yet learned how to do it perfectly, at least I know how it feels to try. That feeling I shall attempt to share with you in this paper.

No other part of English teaching so much depends upon the character, personality, and experience of the individual teacher. That is why reading themes becomes so exhausting; it involves the whole person and draws upon all his resources at once. This is also precisely true of *writing.* The proper critical and corrective reading of anything written by anyone else is a process very nearly the same as the process of original composition, except that the reader is bound by many frustrating restrictions. For, in writing, one is more or less his own master; in *reading for correction,* one must keep all his originality and imagination constantly alert, yet force them to remain the bondservants of the original author. This sensation of working in chains, with every sweep of the eager red pencil checked in midair and then carefully reconsidered and reaimed, is what makes the honest reading of Freshman themes an agonizing task.

I am here tempted to digress on the subject of assigning topics for themes, for much of the ineffectiveness of our composition courses—and much of the teacher's distaste for reading the themes—stem from the lack of motivation in most theme assignments. But that subject is too large for a digression, and I will therefore assume that the themes I refer to are written on topics about which the student has considerable information and which he feels are worth writing about for the hypothetical reader—that none-too-satisfactory audience of college papers. But even the best-motivated themes, written by the most cooperative students, are not easy to read.

It is, of course, quite possible to proofread and "correct" papers with practically no mental effort if one looks only for such crudities as misspelling, faulty punctuation, erroneous diction, and a few other staple defects of that nature. In fact, such reading can be a kind of gruesome fun if you are one of those teachers who love to collect evidence of the illiteracy of the present generation. Indeed, there *is* something primevally pleasant about spearing a fish or spotting a faulty reference—about knocking a squirrel off a limb or ferreting out "undoubtly" or "enviorment." But I maintain that there is also something on the verge of subhuman in hunting without purpose and without full consciousness of the consequences—whether to the squirrel or the Freshman. I have too often noted a cruel gleam in the eye of an instructor as he slashes at student papers. To read themes sadistically is unworthy of a teacher. To read them impersonally is not to read them at all.

For, in spite of handbooks and the venerable Cody's mail-order method, there is far more to good writing than keeping all

* *Presented on June 21, 1950, at a Conference of the English Division during the Annual Meeting of ASEE at the University of Washington in Seattle.*

the rules. Writing is an act of creation. Its purpose is to shape chaos into cosmos and sometimes even to "give to airy nothings a local habitation and a name." No composition, whether an epic or a Freshman theme, is independent of syntax, but literature certainly reached high perfection long before spelling or commas. Under modern conditions of eye reading, these convenient conventions must be observed, but they are none the less superficial. The bones of thought structure and the flesh of living words are what we must teach our Freshmen to handle. If they learn that, grammar, spelling, and punctuation will turn out to be relatively minor problems.

Let me hasten to add, lest you think me a teacher who scorns textual accuracy, that I am a very fussy reader. My pencil scratches savagely—whether on my own manuscript or a student's—at anything which would not do the writer credit in print. That is merely automatic proofreading. But I feel no pleasure at the sight of errors. My purpose is to help the student to learn to write, and that cannot be accomplished by any number of "deletes," "l.c.'s," or even "sp's" in the margin.

The basic problem, then, is to teach Freshmen and Sophomores how to achieve inner as well as outward form. Once, long ago, I took over a Sophomore class which, under a conscientious but very conservative teacher, had learned to beat the rap. Misspellings were rare because these bright boys seldom used a word of more than two syllables. Their punctuation violated few rules because they risked few sentences of more than one clause. Their margins were put in with a ruler, and paragraphs were uniformly indented. *On the surface their themes were printable literature.* But of course they said very little, and what they did say was incredibly dull and pointless. It took me nearly two months, by dint of fresh and, to them, unheard-of indictments, to obtain a good many convictions of literary sin.

That semester fully convinced me that one must insist on positive virtue in writing, not merely neutral innocence. To this day I never meet a new class without remembering my battles with those smug Sophomore writers of short sentences and disjointed paragraphs.

To teach the purpose and the structure of written thought I have, like most teachers, adopted a number of rather obvious devices:

1. I insist on the writer's first deciding what sort of person the "hypothetical reader" is. Without knowing that, writing is a gamble. Therefore, I often ask my students to write down exactly what sort of reader the paper is designed for (the teacher being disregarded in his role of intermediary editor).
2. I ask the student to state what purpose is to be served by his paper.
3. I insist on some sort of outline *before the rough draft is written.* It may be very simple indeed and, if genuine, usually is. To emphasize the dynamic, creative function of such an outline I often call it "doodling," and since I myself habitually doodle out my points as I talk *ex tempore* in class, the students soon perceive the purpose of this preliminary pencil thinking.
4. All finished papers must include the rough draft upon which the fair copy is based. Thus, if I wish, I may look back and see how the composition has taken shape—and, incidentally, I never have to struggle with that monstrosity: a one-draft paper from the pen of an amateur.

Of course students fight tooth and nail *against such stipulations, and year after year try the same tricks to avoid them: the impossibly elaborate outline, written* from the finished product and inserted *into the too-large or too-small space left* in the rough draft, or a rough draft dashed off at full speed and recopied with no attempt at revision. It takes consid-

erable alertness and intuition to save them from such time-wasting dodges, but usually, when they realize that the teacher knows all the tricks, they conform and admit the usefulness of these tools.

But the usual Freshmen, even after they have learned to block out a paper and aim it purposefully, are still helpless to mold the resultant paragraphs into smooth and effective units. Their vocabulary is small, or at least lacking in precision. They have no ear for prose rhythm, no feeling for the texture of a paragraph, no conception of the wonderfully cohesive power of pronouns, little understanding of the value of subordination, and almost no sense of proportion and emphasis. When I was younger, I used to depend on "exercises" to teach these things, but I have found so little correlation between the ability to write well and the ability to fill out blanks "correctly" that I now rely mainly on detailed correction of the individual themes.

How, then, do I personally approach the reading of themes? First of all, I remind myself that the difference between a Freshman theme and the work of Thucydides, Chaucer, or Hemingway is a difference of degree, not of kind. Whether great or little, success or failure, a piece of writing is the effort of one man to communicate with others by words painfully chosen and arranged to the best of his ability. As a participant in this uniquely human activity, even a Freshman deserves respect. No matter how crude the result, his theme should be approached with kindness. He has gone through the throes of literary travail, and, like any other parent, is likely to be sensitive to criticism of his offspring. No matter how harsh I may have to be, I must always make him feel that I have respect and a fellow-feeling for him, the writer, even though I may thoroughly disapprove of his product. For, as I often tell my classes, I hate bad *writing*, but I have nothing but sympathy for the *writer*.

Retaining, therefore, a spirit of kindly fellowship, no matter how weary of themes I may be or how many previous poor grades the student may have received, I open the paper and look it over precisely as if I were an editor in need of good copy. I try first to see what the writer is aiming at, and then begin to read.

From that moment I become two persons, one hovering over the paper as the Olympian editor, the other down among the words and phrases with the struggling author himself. Even as Ego One attacks a bad sentence, Ego Two is at work trying to see how it may be repaired. Ego One objects to everything which he feels will offend the hypothetical reader, while Ego Two humbly accepts his judgment and attempts to touch up the blemish or supply the deficiency. Sometimes, however, Ego One demands the impossible. Then Ego Two remonstrates, and Ego One admits that he is being old-fashioned, pedantic, opinionated, or just plain wrong.

So habitual has this division of personality become that I have learned to produce it at will—much as one can learn to control his vision by preventing reflex interaction of focus and convergence when he wishes to view stereographic photographs without a stereoscope.

This sort of attitude, I find, makes it easy to avoid that cardinal fault of bad editors—demanding that the writer think *my* thoughts and write *my* style. It continually reminds me that a generation separates me and my student—that I write a style with the rhythm and diction of an English teacher born in 1896, which is certainly unsuitable for a boy born in 1933. It warns me to avoid automatic rejection of modernisms and automatic approval of literary phrases and handbook pedantries. And especially it forces me to think of practical solutions to the awkward situations my editorial eye objects to.

Throughout my reading of a paper I try to keep my mind firmly on the subject matter, as if I were an ordinary reader. I proofread as I go, placing appropriate marks in the margin, but I try not to let that activity disturb my atten-

tion to the ideas. Wherever I trip in reading—either because I fail to understand instantly or because I am not sure of what the author means to emphasize—I place some sort of mark—often just a check or an underline. Something must be done about this hiatus, this stumbling block, or this unintentional false clue before the copy goes to press. Just what to do is sometimes a poser, for this is someone else's work. I am not free to "rubbe and scrape" or rewrite whole sentences as I so blithely did when I was preparing the script of this paper. I must point out the trouble to the author, but merely suggest a remedy and let him do the rest. The integrity of a man's own style (even a Freshman's) is almost a fetish with me, and I do not want my student to parrot my words.

So, finally, the margin fills with marks: references to the textbook, questions about the subject matter, indications of misspelling or obviously unacceptable diction, and even, as a final resort, suggested changes couched in my own words—but these last always with a question mark, since the writer himself may well find a better solution than mine. Then, at the end, I usually write some personal comment—sometimes praise, sometimes the reverse, but always something to let the writer know that his paper has been *read*, not merely "corrected."

I have so far been talking about myself, but what about the student? Does he learn to write when his papers are read like this?

I can give only a very personal answer. In my opinion the good student often learns very quickly and even the weak one makes very appreciable progress. At first, of course, students used only to niggling correction of details find it difficult to believe that the teacher really takes their writing seriously—that he means to apply professional standards not only to the outward form but to the innermost convolutions of their thought. But I think a student seldom ends the year without improved powers of thought and expression and a firmer idea of what good writing really is. He is also less self-conscious about his writing. When he sees me, the omniscient teacher, awkwardly struggling with intractable sentences or weighing the advantages of one or another arrangement of points in a paragraph, he realizes two things: that *everyone* has trouble with writing but that, after all, most problems even of writing yield to hard work. He also learns a few of the tricks of the trade, but soon sees that good writing seldom depends upon tricks. And finally, I think, he often generates something very important in the education process: respect for his own work and respect for any teacher who regards him as a fellow craftsman and works with him rather than against him.

To be sure, all this close personal attention exhausts one's store of energy and takes time—much, much time. If I get through five or six 300-word themes in an hour I feel I am better than average that day. Eyesight deteriorates and the spirit rebels. But one thing I have gained: I can now give out semester grades with an easier conscience than I could twenty years ago. And that, I think, balances all the rest.

Exhibit of Teaching Aids at the Seattle Meeting

S G. LUTZ

Professor and Chairman of Electrical Engineering, New York University

A report of those teaching aids exhibited at the 1950 meeting of the Society has been deliberately delayed until this date with the expectation that potential exhibitors for the 1951 meeting who were not at last year's meeting might find some encouragement in learning of what others are doing

The third annual exhibit was held in the Guggenheim Building, University of Washington, under the sponsorship of the Committee on Teaching Aids The exhibit was housed in five rooms with an additional room for the projection of films and slides

One highlight of the exhibit was a simple relay type digital computer, nick named "Simon," which served to demonstrate the important operations of programmed digital computation Simon was built by Robert Jensen and Andrew Vail of Columbia University under the direction of Dr E C Berkeley, author of "Giant Brains" and was demonstrated by Dr Ned Reglein Its dimensions were about 20 inches by 14 inches by 6 inches, and it contained about 100 relays operating from orders and input data supplied from a perforated tape Within its extremely limited capacity of 2 binary digits (decimal numbers from 1 to 4) it was able to demonstrate the most important functions of the larger and faster digital computers

The exhibit of the U. S Air Force Institute consisted of 40 beautifully built dynamic models for use in teaching mechanics Also included in Professor Valey's exhibit were a few cut-away models, photographs, charts etc

Professor W J King of U C L A. exhibited two selectoslide installations with synchronized magnetic recordings, and also an automatic quiz machine set up with questions concerning the California motor vehicle code The U.C L A. exhibit also included a beam theory demonstrator by N E Friedman.

New York University exhibited a switching circuit illustrating a problem in logic, built by Professor James Ley, a rubber dam model of the potential distribution in a triode, built by Professor George Anner, two simple animated cardboard vector diagrams by Professor Lutz, the magnetic field tube built by S. Tetenbaum and the ultrasonic lantern slide control circuit built by George Rand, both under the direction of Professor Lutz, and the use of fluorescent chalk with an ultraviolet light source in classrooms darkened for projection

Other exhibits included a PTZ and three Ternary Phase models of clever spot-welded construction by E A Peretti and E E Hoffman of Notre Dame, plastic planetary gears from Ohio University (Athens), two machine models from Montana State College, two viscosity and lubrication demonstrations from the University of California (Berkeley), as well as a cam motion demonstrator by J. Scheinman The University of Southern California exhibited a complete working model of pipe intersections. From Idaho State, Professor H. O Ritland exhibited a vacuum tube characteristic curve demonstrator built from a war surplus BC929Z radar indicator, while A. E. Taylor exhibited a geiger counter and samples of Idaho radioactive ores.

Because of the location of the 1950 meeting in the extreme northwest few of the eastern schools could send large exhibits, but were well represented by photographs, charts, lantern slides, films and similar items which could be sent by mail. Many of these were photographed in 35 mm. strip film in black and white and were projected with an automatic slide projector with automatic slide changing operated from a magnetic tape recorder which supplied the narration. Thus exhibitors who were not able to be present at the meeting were able to have their material shown and explained. The automatic slide projector was operated continuously and provided approximately a two hour nonrepeating show. The following individuals submitted photographic material which was presented in this fashion:

Professor Edwin B. Weinberg, Sacramento State College, Notes and Solved Problems in Physics for Engineers.

Professor G. S. Timoshenko, University of Connecticut, Details of Electrical Connectors.

Dean E. D. Howe, University of California, Cam Motion Indicator.

Mr. Grant K. Borg, University of Utah, Model of a Sewage Treatment Plant.

Dean L. K. Downing, Howard University, Various Types of Teaching Aids.

Dean W. P. Kimball, Dartmouth College, An A-C Network Calculator.

Professor John M. Hirst, Dartmouth College, An A-C Network Calculator.

Professor A. S. Hall, Purdue University, A Cam Model and a Gear Train.

Professor W. H. Glenn, Jr., John Muir College, Mathematics Models.

Professor J. B. Gribbin, Manhattan College.

Professor R. K. Bernhard, Rutgers University, Instruction Models Used in the Mechanical Vibration Laboratory.

Mr. C. G. Kahlert, Compton College, Photographs Used in Engineering Drawing.

Exhibitors whose displays were shown in the exhibit rooms included the following:

Professor R. S. Hall, Purdue University, Plastic Linkage Models.

Dean E. D. Howe, University of California, Cam Motion Indicator Model.

Dean Paul Cloke, University of Maine, Photographs and Displays of Engineering Problems.

Col. B. W. Bartlett, U. S. Military Academy, Photographs of Electrical Engineering Installations.

Professor A. D. Moore, University of Michigan, Pictures of Fluid Matter Technique.

Professor H. O. Ritland, Idaho State College, Photograph of Model Cyclotron and Devices in Electronics and Engineering Physics.

Dean E. J. Taylor, Ohio University, Lucite Models.

Dean E. W. Schilling, Montana State College, Broaching Mechanism.

Professor E. A. Peretti, University of Notre Dame, Wire Phase-Diagram Models.

Dean R. D. Landon, University of Akron, Photographs of Special Laboratory Equipment.

North Carolina College of Agriculture and Engineering, 120 2-inch by 2-inch slides of models and typical instructional slide material in the various engineering courses.

Professor F. W. Davis, and R. W. Wagner, Ohio State University 16 mm. motion picture film, "Accent on Learning."

Professor Carl W. Muhlenbruch, Northwestern University, Sound-slide film, "Lines of Force."

Professor L. R. Blakeslee, University of Detroit, Photographs and 16 mm. motion picture of building construction for architectural engineers.

It was encouraging to note that many teachers are overcoming their reluctance to exhibit what they consider to be hastily

made teaching aids and which they consider too crude to be placed on display. The annual exhibit serves as a medium for changing IDEAS for teaching aids which any one can build. It is not a trade show of devices to be purchased or of elaborate models made of polished brass and mahogany which are beyond the capacity of many college shops. Elaborate models and automatic projection devices may be entertaining but it is the simple gadgets built in a few minutes from cardboard, paper clips, and other materials that are readily available which are remembered, duplicated, and actually used in classes. The Committee on Teaching Aids hopes that more of these will be exhibited next year. Individuals interested in exhibiting at the Lansing meeting and requiring additional information may forward inquiries to Professor R. J. Jeffries, Department of Electrical Engineering, Michigan State College, East Lansing, Michigan.

ANNUAL MEETING

June 25–29, 1951

MICHIGAN STATE COLLEGE

East Lansing, Michigan

TIMELY TIPS

TIMELY TIPS is a new section in the Journal devoted to unique ways of teaching difficult concepts so that they can be easily grasped by students. Contributions to this section should constitute an improvement over current textbook presentations. They should not exceed two Journal pages in length (including illustrations). If you have novel, short-cut methods of making difficult concepts seem simple, your colleagues will be glad to see them in the Journal. Send contributions of the Editor, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

A Simple Method of Presenting the Combined Variable-Load Equations

By R. T. HINKLE

Professor of Mechanical Engineering, Michigan State College

Many students in Machine Design have trouble with the usual presentations of variable loading. The following method has been used by the author with good results:

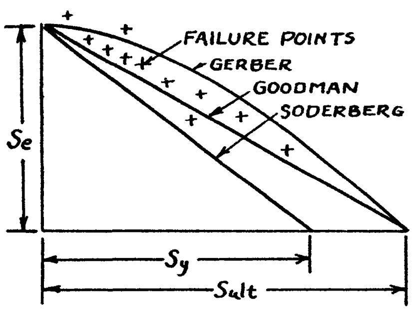


FIG 1

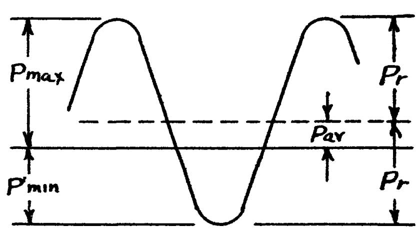


FIG 2

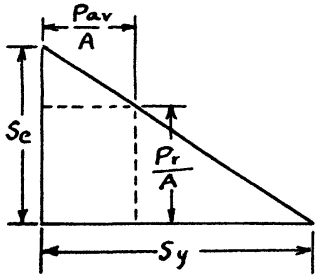


FIG 3

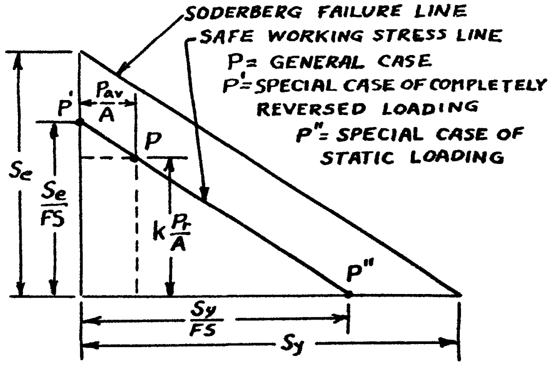


FIG 4

The Gerber, Goodman and Soderberg lines of failure are shown in Fig. 1. These are assumed lines to fit approximately the failure values that have been determined experimentally. It can be seen that the Soderberg line is on the safe side, and is consistent with the general design practice of working with the yield stress rather than the ultimate stress.

A typical type of loading is shown in Fig. 2 where the load varies from P_{max} to P_{min}. This is also shown as an equivalent static load P_{av} and a completely reversed load P_r superimposed upon it. The loading shown in Fig. 2 is also shown in Fig. 3.

From similar triangles,

$$\frac{S_y - \dfrac{P_{av}}{A}}{S_y} = \frac{\dfrac{P_r}{A}}{S_e}.$$

This equation can be written in the form

$$S_y = \frac{\left(P_{av} + \dfrac{S_y}{S_e} P_r\right)}{A}. \tag{1}$$

The student can obtain a physical concept of this by explaining that P_{av} is based on the yield stress and P_r is based on the endurance limit. Now if P_r is increased a certain amount it can be treated as an equivalent static load. The multiplying factor $\dfrac{S_y}{S_e}$ does this. It can be seen that $\left(P_{av} + \dfrac{S_y}{S_e} P_r\right)$ corresponds to P in the static load equation $S_y = \dfrac{P}{A}$.

If the factor of safety is introduced and the stress concentration factor is applied to the variable load, Eq. 1 becomes

$$\frac{S_y}{FS} = \frac{\left(P_{av} + \dfrac{S_y}{S_e} k\, P_r\right)}{A}. \tag{2}$$

If the factor of safety and stress concentration factor are included in the diagram as shown in Fig. 4, Eq. 2 can be obtained directly.

If the appropriate symbols are used in Figs. 2 and 4 the following equations for bending and torsion can be obtained:

$$\frac{S_y}{FS} = \left(M_{av} + \frac{S_y}{S_e} k\, M_r\right)\frac{c}{I}, \tag{3}$$

$$\frac{(S_s)_y}{FS} = \left(T_{av} + \frac{S_y}{S_e} k_t\, T_r\right)\frac{c}{J}. \tag{4}$$

The ratio $\dfrac{S_y}{S_e}$ can be used with T_r because it is very nearly equal to $\dfrac{(S_s)_y}{(S_s)_e}$.

Here again, the terms $\left(M_{av} + \dfrac{S_y}{S_e} k\, M_r\right)$ and $\left(T_{av} + \dfrac{S_y}{S_e} k_t\, T_r\right)$ correspond to M and T in the static load equations,

$$\frac{S_y}{FS} = M\frac{c}{I} \tag{5}$$

and

$$\frac{(S_s)_y}{FS} = T\frac{c}{J}. \tag{6}$$

The equation for combined shear and direct stress is

$$\frac{(S_s)_y}{FS} = \sqrt{\left(\frac{\frac{S_y}{FS}}{2}\right)^2 + \left(\frac{(S_s)_y}{FS}\right)^2}. \tag{7}$$

The equation for combined moment and torque on a solid circular shaft (Eq. 8) is obtained by substituting Eqs. 5 and 6 in Eq. 7.

$$\frac{(S_s)_y}{FS} = \frac{16}{\pi d^3}\sqrt{M^2 + T^2}. \tag{8}$$

In a like manner the Westinghouse equation for the design of solid shafting (Eq. 9) is obtained by substituting Eqs. 3 and 4 in Eq. 7.

$$\frac{(S_s)_y}{FS} = \frac{16}{\pi d^3}\sqrt{\left(M_{av} + \frac{S_y}{S_e}k\,M_r\right)^2 + \left(T_{av} + \frac{S_y}{S_e}k_t\,T_r\right)^2} \tag{9}$$

or Eq. 9 can be obtained directly by substituting the equivalent fatigue values $\left(M_{av} + \frac{S_y}{S_e}k\,M_r\right)$ and $\left(T_{av} + \frac{S_y}{S_e}k_t\,T_r\right)$ for M and T in Eq. 8.

It can now be shown that the simple equations for static and for completely reversed loading are special cases of the more general equations. This is shown in Fig. 4 by points P' and P'' and can also be shown by making the appropriate symbols in Eqs. 3, 4, or 9 equal to zero.

This presentation follows closely the work that the student is already familiar with and is integrated with it. It should not remain as an isolated bit of his mental working equipment, or, as is often the case, never fully understood and soon forgotten.

THE T-SQUARE PAGE

Officers
R. S. Paffenbarger, *Chairman*
O. W. Potter
T. T. Aakhus
C. J. Vierck
J. S. Rising
H. E. Grant

Devoted to the Interests of Engineering Drawing

J. Gerardi, *Editor*
University of Detroit

Officers
I. L. Hill
J. G. McGuire
W. E. Street
C. E. Rowe
H. C. Spencer
W. J. Luzadder

ENGINEERING DRAWING SUMMER SCHOOL

Michigan State College

June 21–26, 1951

The Executive Board of the ASEE has formally approved sponsorship of the Engineering Drawing Division Summer School to be held in connection with the Annual Meeting at Michigan State College. This will start four days previous to the Society meetings which is Thursday, June 21, 1951, and conclude with our regular sessions allotted during the following week.

The general theme of this school will be "Improving our Status as Teachers of Engineering Drawing" treated on a basis of:

(a) Meeting curriculum requirements
(b) Teaching methods by lecture demonstrations
  1. Basic Drawing
  2. Descriptive Geometry
  3. Advanced Drawing
  4. Elementary and Advanced Graphics
(c) Industrial applications

Proposed program including time allotted during Annual Meeting

Thursday, June 21, 1951

Morning
8:00– 9:00 Registration.
9:00–12:00 Papers and discussions dealing with courses, administration reproduction, tests, credits, etc.

Afternoon
2:00– 4:30 Papers and discussions continuing with morning topics—Teacher Training, etc.

Evening
6:00– Dinner. Social gathering
7:30– Tour of displays with discussion by exhibitors. Directed by Committee on Exhibits

Friday, June 22, 1951

Morning
9:00–12:00 Teaching Methods. Lecture demstrations with discussion on Basic Drawing

Afternoon
2:00– 4:30 Teaching Methods. Lecture demstrations with discussion on Descriptive Geometry

Evening
7:30– Teaching Aids. Exhibits and discussion directed by Committee on Teaching Aids

Saturday, June 23, 1951

Morning
9:00–12:00 Teaching Methods. Lecture demstrations with discussion on Advanced Drawing
12:00– Group picture

Afternoon
2:00– 4:30 Teaching Methods. Lecture demstrations with discussion on Elementary and Advanced Graphics

Evening
6:00– Dinner. Executive Committee dinner

Sunday, June 24, 1951

Open for visits to Detroit, Ann Arbor, and Dearborn, University of Detroit, Wayne University of Michigan, Greenfield Village, etc.

Monday, June 25, 1951

Morning
9:00– Inspection trips

Afternoon
2:00– Conference. Industrial Application, papers and discussion

Tuesday, June 26, 1951

Morning
8:30– Inspection trips
10:00– Conference
12:00– Luncheon, Business meeting and Committee reports

Afternoon
2:00– Conference. Industrial Application, discussion

Evening
6:00– Dinner (ladies invited)
Awards
Jim Hays, Michigan State College "The Mechanical Cow"

The local committee at Michigan State College making arrangements at East Lansing for this Summer School consists of Professor C. L. Brattin, Chairman; O. W. Fairbanks; N. R. Sedlander; R. O. Ringoen (all of Michigan State College); Professor Philip O. Potts, University of Michigan; Professor Ralph T. Northrup, Wayne University; and Dean Jasper Gerardi, University of Detroit.

The Division is planning to exhibit student work in engineering drawing, course outlines, foreign drawings, drawing instruments and materials, visual aids and other displays which will be of interest to engineering teachers.

A cordial invitation is extended to all members of the Society who are interested in this program.

Ralph S. Paffenbarger, *Chairman*
Division of Engineering Drawing, ASEE
The Ohio State University

Candid Comments

The First Engineering School

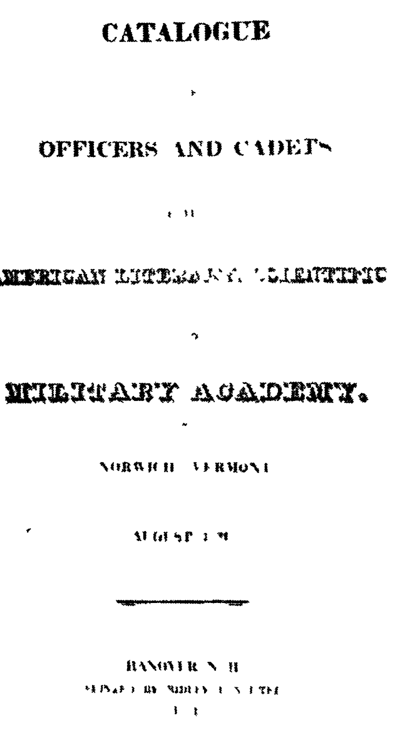
Referring to the article, "A New Approach to the Doctor's Degree for Engineers," by D. H. Pletta, in the November 1950 issue of the JOURNAL OF ENGINEERING EDUCATION.

I have just noticed in Table I, page 163 of the above, where it is stated in this table, that the first college course in engineering was that instituted at Rensselaer in 1828.

That statement simply perpetuates a long-standing error, namely, the idea that the first engineering course given in the United States was that at Rensselaer.

Enclosed is a reprint of our article in *Civil Engineering*, May 1950, page 68, relative to that historical fact of Norwich University being the FIRST EDUCATIONAL INSTITUTION IN THE NATION TO TEACH CIVIL ENGINEERING beginning in 1819.

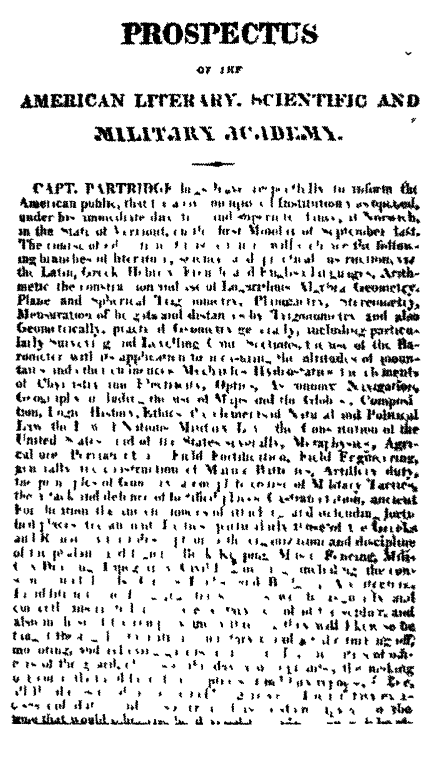
Please notice that historical records show that a group of some twenty young men —who later became well-known Civil Engineers—received their early instruction in civil engineering at Norwich (then the Academy) in the period of 1819 to 1825. This was several years before Rensselaer had opened her doors, which in their own history, "History of the Rensselaer Polytechnic Institute" by Palmer C. Ricketts, they date as 1824,



CATALOGUE

OFFICERS AND CADETS

MILITARY ACADEMY.



PROSPECTUS

OF THE

AMERICAN LITERARY, SCIENTIFIC AND

MILITARY ACADEMY.

CAPT. PARTRIDGE

first classes in 1825. The historical records of these twenty or more young men are in the files of Railroads by which these men were later employed in Civil Engineering work, and are also given in the three volume "History of Norwich University" 1819–1911.

Two of this very early group of some twenty young men, Norwich graduates of 1824, were Moncure Robinson, famous railroad engineer, and Alfred Wingate Craven, long chief engineer on New York City's early Croton water supply (both noted in the article reprint), (and also a third one, William S. Campbell, Norwich '28) were very active in the founding of the American Society of Civil Engineers. And Craven was the fourth President of the ASCE. Further, they are prominently recorded, several places, in the volume "Historical Sketch of the American Society of Civil Engineers" by Charles Warren Hunt.

Further, in Rensselaer's history by Ricketts, noted above, page 79, refers to the catalogue published in 1828, and also there refers to—"lectures on land surveying and civil engineering." And further quote from page 79, "This is the first appearance of the term 'civil engineering' in any of the circulars, and no well-defined course in the subject was formulated for several years." That was nine years or more after the beginning of Civil Engineering teaching at Norwich.

Norwich University thus precedes Rensselaer in the teaching of Civil Engineering by at least five years, before Rensselaer had opened her doors, or nine years or more by their own Rensselaer history taking their 1828 or "several years" later date.

David L. Snader
Head Department of Civil Engineering, Norwich University

Thermodynamics Summer School

June 28–July 7, 1951, Michigan State College

A Summer School in Thermodynamics will be held at Michigan State College, East Lansing, Michigan, June 28–July 7, 1951, at the close of the Annual Meeting of the ASEE. Methods of better teaching of the elementary thermodynamics will be presented as well as modern developments in the field of thermodynamics and a little on advanced theory. In addition, more background material for the teacher will be provided.

The following is a tentative program: June 28, "Leading the Student of Thermodynamics to Think," "Teaching the Concept of State Properties, Boundaries, Systems, etc."; June 29, "First Law of Thermodynamics," "Effective Presentation and Modern Approach to the Second Law of Thermodynamics," "Energy Transfer from the Laws of Thermodynamics," "Fluid Mechanics and Thermodynamics"; June 30, "Availability and Reversibility," "Mathematical Approach to Kinetic Theory of Gases," "Kinetic Theory of Gases and Thermodynamics"; July 2, "Basic Physical Chemistry for Thermo Teachers," "Physical Chemistry and the 1st and 2nd Law of Thermo," "Integration of the Physical Chemistry Approach to Thermodynamics"; July 3, "Visual Aids in Teaching Thermodynamics," "The Atomic Age: How to Equip Engineering Students for It," "Thermodynamics of Gasoline Engine Cycles"; July 4, "Thermodynamics of Vapors: Preparation of Vapor Tables"; July 5, "Combustion Theory: Combustion in Stationary Boilers," "Steam Turbines and Power Plant Design"; July 6, "Theory of Jet Engines," "Combustion in Jet Engines"; July 7, "Gas Turbine Design," "Compressor Design," "Compressor Flow."

A registration fee of $10 will be charged.

Shorter, Less Expensive Pre-Engineering Test Now Available

With the aid of the joint ASEE–ECPD Advisory Council the Measurement and Guidance Project in Engineering Education has devised certain improved testing services for engineering colleges.

I. To meet the need for a short, inexpensive, and easily administered test generally quite predictive of scholastic success in engineering colleges, *a new 80-minute Pre-Engineering Ability Test* will be offered for sale by Educational Testing Service on and after July 1, 1951.

Derived from the two most predictive parts of the Pre-Engineering Inventory, the new 80-minute test is estimated to have a validity nearly as high as for the composite score from the Inventory. Norms carefully equated to the original national norms will be furnished so that the test can be effectively used as soon as purchased.

A cost of 12 to 15 cents per examinee for test materials is made possible by separate answer sheets and reuse of each test book four to six times. Answer sheets and test books will be sold in packages of twenty-five; answer sheets for 80 cents per package; books for 40 cents each or $10 per package. Scoring stencils are 25 cents each (only one is needed). The sale of tests is restricted to colleges and to technical institutes accredited by ECPD.

II. After January 1, 1951, users of the Pre-Engineering Inventory who prefer to continue to use the four-hour "Short Form" or the six-hour "Long Form" may *purchase* test books, answer sheets, and scoring keys. Only engineering colleges and ECPD accredited technical institutes may purchase the tests. A cost of 50 to 60 cents per examinee is made possible by separate answer sheets and reuse of test books four to six times.

Under this new plan the costs are as follows:

	Test Books	Answer Sheets	Scoring Stencils
Unit of Sale	One book or one set of two books	Package of 25 sets	One set
Cost			
Short Form	$1.50 per book	$2 per package	$1 (4, one for each test)
Long Form	$2 per set of two books, I and II	$2.50 per package	$1.50 (7, one for each test)

Some of the test books may have been used previously but all are in excellent condition. Books usually can be reused five to eight times. Only the inexpensive answer sheets need be repurchased.

Educational Testing Service will score and report scores on an alphabetical list at a cost of $1 per examinee for the Short Form, $2 per examinee for the Long Form. For an additional $0.75 per examinee, distributions will be furnished comparing the group tested against national norms.

Individual announcements of these new services have been mailed to deans of engineering and to other interested persons. Further information may be obtained from Dr. A. Pemberton Johnson, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner, Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Fall, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University U. S. Naval Post Graduate School	Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 28–29, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

New Members

Adler, F. T., Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh 13, Pa. D. F. Miner, J. W. Graham, Jr.

Archer, Oscar D., Dean, Lamar State College of Technology, Beaumont, Texas. L. B. Ryon, A. J. Hartsook.

Biscoe, Jonathan, Associate Professor of Physics, University of Maine, Orono, Me. C. E. Bennett, W. S. Evans.

Bishop, John A., Associate Professor of Chemistry, Newark College of Engineering, Newark, New Jersey.

Brady, Sherwood J., Assistant Professor of Engineering, San Jose State College, San Jose, Calif. R. J. Smith, J. H. Anderson.

Clarke, Charles B., Assistant Professor of Civil Engineering, Rhode Island State College, Kingston, R. I. A. A. Collard, T. S. Crawford.

Cooper, George R., Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, H. A. Bolz.

Cornwall, Richard R., Instructor in Chemical Engineering, School of Mines, Rolla, Mo. F. H. Conrad, D. S. Epplesheimer.

Crispen, Robert E., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. H. Sutherland, P. F. Miller.

Dominic, Randolph P., Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. F. P. Beer, P. F. Miller.

Durst, Richard E., Associate Professor of Chemical Engineering, University of Maine, Orono, Me. W. S. Evans, F. M. Taylor.

Eppes, James Van D., Associate Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa., P. F. Miller, J. B. Hartman.

Erkiletian, Dickran, H., Jr., Assistant Professor of Mathematics, School of Mines, Rolla, Mo. R. M. Rankin, D. S. Epplesheimer.

Gale, Grant O., Professor of Physics, Grinnell College, Grinnell, Iowa. A. B. Bronwell.

Gebhart, Benjamin, Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. P. F. Miller, M. C. Stuart.

Gentile, Jerry J., Assistant Professor of Civil Engineering, Rhode Island State College, Kingston, R. I. A. A. Collard, T. S. Crawford.

Isbin, Herbert S., Assistant Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn. N. A. Amundson, N. H. Ceaglske.

Jentoft, Arthur P., Graduate Assistant, Civil Engineering and Mechanics, Lehigh University, Bethlehem, Pa. W. J. Eney, P. F. Miller.

Johnston, E. Russell, Assistant Professor of Civil Engineering and Mechanics, Lehigh University, Bethlehem, Pa. G. J. Christiansen, P. F. Miller.

Keevil, Charles S., Personnel Director, Arthur D. Little, Inc., Cambridge, Mass. W. C. White, C. P. Baker.

Kline, Lee B., Instructor in Engineering Extension, University of California, Los Angeles, Calif. J. C. Dillon, C. M. Duke.

Kochenburger, Ralph J., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. K. C. Trippy, E. V. Gant.

Lamm, Earl S., Assistant Professor of General Engineering, Purdue University, Lafayette, Indiana. H. T. Amrine, M. D. Roberts.

Macdonald, Albert E., Dean of Engineering and Architecture, University of Manitoba, Winnipeg, Manitoba, Canada. A. B. Bronwell.

Mack, James D., Librarian, Lehigh University, Bethlehem, Pa. G. J. Christiansen, P. F. Miller.

Nolte, Roger E., Assistant Professor of Electrical Engineering, School of Mines, Rolla, Mo. I. H. Lovett, D. S. Eppelsheimer.

Nordby, Gene M., Instructor in Civil and Architectural Engineering, University of Colorado, Boulder, Colo. M. W. Jackson, W. Raeder.

PETERSON, RAYMOND C. W., Owner and Chief Engineer, Peterson Engineering Co., Toledo 2, Ohio. W. F. Rohr, W. G. Rohr.

RICE, EDWARD K., Research Engineer, Institute of Engineering Research, University of California, Berkeley, Calif. A. S. Levens, J. C. Dillon.

RIPLEY, JULIEN A., Head of Physics Department, Montgomery Junior College, Takoma Park, Md. C. E. Bardsley, H. H. Armsby.

ROWE, ROBERT S., Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. K. H. Condit, F. A. Heacock.

SAMPSON, ROGER W., Instructor in Electrical Engineering, University of Florida, Gainesvile, Fla. F. H. Pumphrey, L. E. Schoonmaker.

SMITH, NORMAN L., Assistant Professor of Chemical Engineering, School of Mines, Rolla, Mo. W. T. Schrenk, F. H. Conrad.

SMITH, WESLEY C., Assistant Professor of Engineering, Pennsylvania Military College, Chester, Pa. F. L. Marton, J. D. Beatty.

SMUTZ, MORTON, Assistant Professor of Chemical Engineering, Bucknell University, Lewisburg, Pa. W. D. Garman, H. D. Sims.

STRAUSSER, HOWARD S., JR., Instructor in civil Engineering and Mechanics, Lehigh University, Bethlehem, Pa. P. F. Miller, J. O. Liebig, Jr.

306 new members this year

ANNUAL MEETING

MICHIGAN STATE COLLEGE

June 25-29, 1951

EAST LANSING, MICHIGAN

Professional Registration of Engineers

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee and Chairman, Tennessee State Board of Architectural and Engineering Examiners

Introductory

Engineering registration is certification by the state that a practitioner has met at least the minimum educational and experience requirements set up by law to practice the engineering profession. The practitioner may be qualified far above the minimum but the state does not undertake to recognize degrees in qualification.

Registration gives legal status to the registrant. All persons are responsible for their acts but when the law has been passed, the responsibility may be quite different for those who are registered and those who are not. Unregistered persons may not collect professional fees; they may be liable for criminal negligence in case of disaster or they may be guilty of misdemeanor in case of ordinary practice.

During the period in which registration laws were being passed, many questions were raised as to legality, desirability from a professional point of view and feasibility of enforcement. Time has answered all these questions. The legality is based upon the police power of the state to protect life, health, safety and property. This is a very old power assumed by government almost as soon as government was organized and certainly assumed along with its power to protect itself. The state has a right to do anything necessary to protect itself and protect the lives of its people, the health of the people, their safety, and of course, to protect their property.

When the Constitution was written the states retained the police power for themselves and only gave the Federal Government such powers as were necessary for specific tasks; their own powers to protect their citizens were not changed or abridged. Almost the first question asked by the neophite is: "Why not pass a Federal law instead of all the state laws?" The reason has just been stated; the Federal Government was not given the needed police powers for this purpose.

The desirability of registration laws has been debated by engineers since the turn of the century. Always there have been two sides to the questions but the affirmative side has won. In the early days the opponents were the unqualified and the well qualified, while the proponents were usually the large group of engineers in between the extremes. The unqualified did not want to be left out; the well qualified were doing well without a law.

Some have said that registration was not feasible because of many bogie difficulties. Engineering could not be a profession because it had no relation of confidence; engineering covered such a wide range of activities that it was practically impossible to write a definition, and finally, if a law were passed it could not be enforced. Engineering does have a relation of confidence; it can be defined and the laws can be enforced. Laws have been passed in all the states, the District of Columbia and the territories of Hawaii, Puerto Rico and Alaska.

Demands Upon Education

Educators are interested in registration because all their graduates and many of their other students will practice in a world where registration is an accom-

plished fact. All the states have it. Slowly, but surely, registration is becoming a part of civil service procedures; it has already become a state requirement for engineering work and as a qualification for employment. Industry has begun to take notice of its meaning. Educators should have their say regarding the laws of the future. Medicine requires a minimum education for practice; the trend is toward engineering graduation for admission to engineering.

The doors are still wide open, and they should be, but the time is coming when a much stricter requirement for education will be a part of professional qualification. The road to engineering practice leads through the engineering college; tomorrow, or the next day, it will be through graduation.

Registration will have an effect on education; registered engineers are speaking their minds on the subject. More registered engineers will be introduced into the faculties. Registration had as much to do with ECPD accrediting as any other engineering agency. State Boards wanted to know the meaning of: "Graduation from a college satisfactory to the Board"; now they have a list of such colleges.

As engineers study education, they will become more vocal about it. They have something to offer; educators have something to offer in the conduct of the registration business.

Right now State Board examining procedures need your help in determining when a candidate is educated. Engineering practitioners on the boards have much faith in written examinations; you have been giving examinations all your professional careers and some of you do not have too much faith in them. You should help the engineers in your state to validate their examinations; they should not be an ordeal, but should be designed to determine qualification to practice engineering.

History of Registration

The government began to regulate medicine and in some cases, the practice of law, a long time ago. For example: Hammurabi had in his code a regulation for medical practitioners. The practitioner could operate on a believer but he must be right; if his patient died the practitioner was guilty of murder. The surgeon had three tries on an unbeliever and if they all died he had to quit the profession.

> "Certain standards for admission to the medical profession have been recognized since the beginning of history. Even in ancient Rome the requirements were defined by legal action in an attempt to protect the public from practitioners who were considered not qualified to treat the sick. . . . From the beginning the object has been the protection of the public, not the protection of the physician."
>
> Justin-Miller—
> *The Philosophy of Professional Licensure*

The registration of engineers, however, is quite new. It began with the state of Wyoming in 1907 and extended to all of the forty-eight states by 1947. Montana, a neighbor of Wyoming, was the last of the forty-eight states to pass a registration law. Forty years of legislation were required to make registration universal.

The curve of enactment of laws shows that many factors had an influence on their passage. For example, legislation started in 1907 and gained ground slowly; then came World War I, which catapulted the engineer into the general civilization of the world and pointed to the fact that engineering activity is an important activity in any community. As a result, impetus was given to the registration movement. Many laws were passed between 1919 and 1928, then there was a slowing off; finally, the last law was passed in 1947, thus making a complete roll of all the states and territories.

During the whole period the technical societies were interested in the movement. At first they were against it, largely because the older members of the profession were in charge of the societies; then they became lukewarm, and finally, they joined in the movement. In the late teens the

engineers began to realize that the movement was gaining and that being nominally against it would not stop it. They prepared a Model Law and recommended it to the states. The societies did not recommend the passage of such a law but, if locally, the engineers insisted, here was what they should do. Many states did accept the Model Law as the desirable type of legislation. Others passed their own law to suit their own local ideas. Had the engineering societies come out for the movement as early as 1911, when the first Model Law was proposed, they would have had more influence on getting uniformity.

The next great series of improvements will probably come in uniformity of laws, uniformity of practice, and better enforcement. Another thing which will be essential is more universal application of registration to the profession. There are thousands of engineers in the United States who are exempted under provisions of the acts but who should be registered because they will ultimately undertake activities which are covered by state legislation.

Objectives of the Movement

What is all the shouting about? What were the engineers trying to do when they passed the first law in Wyoming? Water in that state was very important. In order to get water permits, someone had to file a map with the state showing the need of water and what the individual or organization was going to do with it. Maps were drawn by almost any person who could make a pencil sketch. As a result, there were conflicting claims and overlapping areas. Wyoming passed a law to be sure that the claims were reasonable and that the surveying was good. After the law was passed in 1907, the situation was cleared up immediately. This was a local situation and was solved in a local way.

Another example is on the Pacific Coast. The architects in California passed a law preempting certain structural activities to themselves. The engineers were being legislated out of a job in their field. They decided that the thing to do was to pass a law of their own in order that they might get back some of the structural activity which the architects were assuming. They passed the Structural Engineers Registration Law allowing engineers to design buildings and other engineering structures. This again was a local situation, but it did not continue to be local because the same problem arose in other states.

The object of Engineering Registration is to protect the public against incompetence; and incidentally, to protect the practitioner from incompetence. Practically all engineering activity has to do with some phase of public health and public safety; the design of a bridge, a water supply, a sanitary structure, a drainage structure, a machine, an airplane or an electric distribution system, all have to do with public safety and public health. If incompetent practitioners undertake work which engineers normally do, the public is involved and often put in jeopardy.

For the practitioner, the incompetent usually competes on a different level from the competent practitioner. He undertakes to do his work with the least amount of cost and as a consequence, he is willing to work at a lower price than the competent practitioner. One will prepare satisfactory plans and specifications, the other will try to get by. The general public is benefited, the practitioner is benefited because of the removal of the incompetent practitioner from his sphere of competition.

I like to think of the whole movement of registration as being a much larger thing than just the weeding out of the incompetent. It is part of the greater effort to get professional consciousness and professional recognition. During the last fifty years there has been an avalanche of joint activity to find a place in the sun. Engineers realize that their education is not ordinary education; it is in the category of professional and they are trying to find a place for them-

selves among the recognized professionals.

Registration places a badge on the initiate, it certifies that his friends think well of him; that he has had a minimum of education and experience; and that he is a beginning professional. These are important elements of the general problem of professional recognition.

The classification of "Engineer-in-Training" has been included in the Model Law for recent graduates and persons with limited engineering experience in order that they may identify themselves with the profession before they have achieved full professional status. Several of the states have included the classification and are using it for the training period between graduation and registration. In a recent paper Dr. Steinman, in American Engineer, lists the objectives of the engineer-in-training:

1. To give the young graduate professional identification and professional consciousness.
2. To start him on the road to professional qualification and recognition.
3. Through professional identification, to protect him from the inroads of unionization.
4. To facilitate relations of guidance, counsel, and cooperation by older engineers.
5. To expedite and facilitate the attainment of full professional certification.

One of the major objectives was to give professional affiliations in such a way that the beginner would be protected against having to join groups which were not to his liking. If the young engineer wishes to join groups of his own, that is his business, but he should not be forced into any organization against his will.

How It Works

Registration must be by the profession itself. The very nature of the license is such that only a person versed in the profession can determine those who are qualified. The state delegates to an engineering board the authority to set up rules for determining education, experience and responsibilty necessary to practice. The law is the general charter for their activities, and of course the Board must be fair and just, both to the public, and to the practitioner. The major object is to protect the public and not the practitioner.

Should the profession believe that it has a vested right to determine who should be admitted and thus arrogate unto itself unfair methods of determining qualification or discriminatory methods of issuing certificates the state would step in and rectify the matter. Should a profession try by law to fence in certain privileges for itself it will come to legislative grief. Examples of this type are the architects trying to preempt structures and lawyers trying to preempt writing deeds.

To operate the law, a renewal fee is necessary. This sets up a peculiar situation, that on December 31 a man is perfectly competent to practice and on January 1st he may be ineligible if he has failed to pay his fee. This is merely a legal technicality. He is just as competent, but to operate the law, the board must have funds and the state has said that the registrants must pay for the expense of the regulation.

Throughout the whole registration movement there has been difficulty with inter-state registration. Some of the laws provide that persons registered in other states, having requirements equivalent of their own, may be registered in the state on such evidence. We, in Tennessee, accept registrants from other states because our law allows us to do so. Some states make it quite difficult for a person to transfer from another state to their state. The National Council of State Boards of Engineering Examiners has done good work; it has set up a registration bureau, which investigates records, statements of experience, education, and finally, certifies its findings to all state boards. Many of the boards can use the

certificate as competent evidence of qualification; others can use it as additional evidence; and finally, a few states do not accept the National Council certificate at all. The National Council, of course, has no authority to register anyone; registration is a state authority and cannot be delegated to any national council.

Results of Registration

What has been achieved by Engineering Registration? First, certain local problems have been solved, as for example, the Wyoming and California problems and other similar problems which have developed in other states. There has been a great growth towards unity in the profession. Registration has had its part; it may not have been the prime mover in the unity but at least it is one activity in which all engineers may engage. They can take an active part in seeing that only competent persons are registered and seeing that only competent practitioners are in the field.

Those of us who have been in the movement believe that we have better public understanding. The state has recognized the profession as having legal status. As a result, the people in the state understand better the difference between a professional and a non-professional. Of course, this same objective is being promoted by the Technical Societies and the National Societies throughout the states and through their local branches.

It has set up a definition of professional status—graduation plus four years experience—or eight years experience with an examination. This type of qualification is becoming the minimum for recognition of professional status. The National Technical Societies have before them now, the recommendation of ECPD to make this requirement the minimum for membership in a society. If the societies adopt the same nomenclature and the same requirements for grades of membership, their titles will mean the same throughout their membership and they will have the same requirement as the State Examining Boards.

There has been a strong incentive for self improvement in borderline cases. Written examinations have been required. There have been a number of repeaters who finally passed the examination. This has meant home study, extension courses, and coaching to get an improvement in their educational background. Certainly the competent have not been injured and the beginners have been improved.

The movement has swept the whole country. It began in Wyoming and ended in the adjacent state of Montana; all the other states having passed laws during the period. We are no longer in the beginning of the registration movement but probably nearing its noontide. The next great step, as I have said before, will be to improve the registration laws, to get better enforcement; to make the laws apply to all practicing engineers and to make it easier for engineers to pass from state to state.

Signs of Our Times*

By HAROLD E. WESSMAN

Dean, College of Engineering, University of Washington

What are the signs of our times, which, reflecting the experience of the past and the achievements of the present, point the way toward distant horizons? What do the signs of our times suggest as to the world of tomorrow?

The historian would have one answer to these questions. The philosopher another. The sociologist still another. How would the engineer or the scientist answer such questions? It is an intriguing occupation to journey beyond the horizon and visualize the scene twenty-five or fifty years hence. In fact, it is almost impossible to seek the answer to some immediate engineering problem without keeping one's eyes on distant horizons. Every research worker in accepting and meeting the challenge to fill a gap in our knowledge has seen the boundary of that knowledge move farther and farther away as he learned and discovered more and more.

There has never been a fixed frontier in science and technology. Every new development has pushed the frontier farther and farther toward the infinite. We may think we see the horizon line for the immediate present, but if the lessons of the past have any meaning whatsoever for us, we know that beyond that horizon lies another and another and yet another. No surveyor of the finite universe will ever be able to stake out the horizon line, write a legal description of it, and file it away in the county recorder's office for posterity.

What lies beyond the horizon? What will the world be like in 2000 A.D.? What will man be like? His religion, his society, his economics, his politics? Where will the advance guard of science rest? How far will the main body of technology have progressed? How will life be affected by the constantly accelerating impact of science and technology?

Yes, it is fascinating to let your mind wander into that land beyond the horizon, whether you be scientist, engineer, philosopher, economist, or poet.

"For I dipt into the future, far as human eye could see,
Saw the Vision of the world, and all the wonder that would be;

Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales;"

Lord Tennyson, in meditation more than 100 years ago "with the fairy tales of science, and the long result of time," thus brings to us his dream of the coming air age. It was sheer fantasy at the period when Tennyson wrote "Locksley Hall," but we know it as accomplished fact of today.

Others, before and since Tennyson, have attempted to lift the veil which hides the future from the present. Forty years ago H. G. Wells wrote his excursion into the 22nd Century, "The Sleeper Awakes." His descriptions of radio, television, and aeroplanes written at a time when no one of these existed were amazing and unbelievable. Viewed in the light of current developments in these fields, we realize how amateurish were his conceptions in his earlier writings. Instead of

* Presented before Civil Engineering Division, ASEE, June, 1950.

waiting 200 years for the fulfillment, science and engineering, in the short span of 40 years, have brought the aeroplane and radio to a point far beyond that which Wells, even with his vivid imagination, could visualize.

Edward Bellamy in "Looking Backward" moved his main character, Julian West, forward only 113 years from 1887 to 2000 A.D. and by this device gave us a look at Boston 50 years hence. Bellamy's Utopian dream, which seems to have overlooked the nature of human nature, does not take one on the detailed engineering excursions which characterized the Wellsian dreams. Nevertheless, he portrays a new Boston, one which is extremely pleasant to contemplate.

In the Limit

Yes, it is fascinating to journey "beyond the horizon," but if you wish a pleasant voyage, do not travel to the end of time, billions of years hence, when according to the astronomers, all processes of nature will cease. Lincoln Barnett in his recent book, "The Universe and Dr. Einstein," encourages us to a non-productive existence during our short stay in this world by stating, "All the phenomena of nature, visible and invisible, within the atom and in outer space, indicate that the substance and energy of the universe are inexorably diffusing like vapor through the insatiable void. The sun is slowly but surely burning out, the stars are dying embers, and everywhere in the cosmos heat is turning to cold, matter is dissolving into radiation, and energy is being dissipated into empty space. . . . There will be no light, no life, no warmth —nothing but perpetual and irrevocable stagnation. And there is no way of avoiding this destiny. For the laws of nature—and in particular the fateful principle known as the Second Law of Thermodynamics—assert that the fundamental processes of the universe are irreversible."

When we contemplate that uncomfortable ending in store for this universe, it is only natural for us to ask the astronomer-scientist, "But can you prove that there will not be another universe?" I am not a theologian, but I do have enough faith in life eternal to say to the unborn generations billions of years hence, "Cheer up! There was an Origin, a Creation, call it what you will, of this universe in which we now live. I am sure that there will be another Creation and another universe for you and that Life in your age will be even richer and more beautiful than Life is today."

There are those who would take issue with that statement. They are those who say that civilization with its wars, its problems of today, moves backward rather than forward. They point to the Golden Age of Literature, to the glories of ancient Rome and Greece, to that high level of intellectual culture which characterized the citizens of Athens five centuries before Christ, and they cry, "Let us go back to the good old days." To them I would say, "Take an excursion with the Connecticut Yankee to King Arthur's Court, or for that matter, travel with Peter Standish of Berkeley Square, London, from the year 1928 to the year 1784—to an England saturated with disease, cruelty, and indescribable filth, an England so smelly that Peter Standish in a dramatic climax exclaims, "God, how the Eighteenth Century stinks!"

One does not have to be a sanitary engineer to appreciate the march of progress in removing the stench which pervaded the atmosphere of the cities and towns of our forefathers. I am certain that he who yearns for past glories would, if transported to that day and age, soon want to come back to his electric lights, his refrigerator, his radio, his automobile, and his bath. Yet, he would soon wish to return to this age of science and technology where the lot of the common man with all his trials and tribulations is infinitely better than that of 100 years ago —to this day in the United States of America when the common man not only

has time for philosophical contemplation, but what is infinitely more important, the chance to become an uncommon man. And it is no coincidence that it is here in our America under a system of private ownership and free enterprise that science and technology have made the greatest strides, and that the average man enjoys the highest standard of living in the world.

The Pinnacles of Research

What are some of the outstanding research developments during the past decade in various fields of engineering, developments that will have a profound influence on the world of tomorrow? To get the answer to that question I consulted a number of my engineering friends in different universities. The following $64 question was presented to them: "What do you consider the three most significant research developments in your field during the past ten years?"

As one might expect, there were differences of opinion, but nevertheless there was enough agreement to focus attention on certain achievements in each major field. Radar, television, servo-mechanisms, and electronic computers highlighted the realm of electrical engineering. Synthetic rubber, fuels, and the recovery of magnesium from sea water stood out in chemical engineering. The aeronautical engineers believed that the flight of man at supersonic speeds was the most remarkable achievement in recent years, but they noted that this rests upon a host of research studies in aerodynamics, in aircraft structures, and in aeroplane power plants. The mechanical engineers listed jet engines, rocket engines, and stress analysis of metal parts subject to high speed and high temperatures. Civil engineers listed research on airport pavements, super-highways, reinforced-concrete slabs, aerodynamic studies of suspension bridges, and filter processes in sewage disposal. The metallurgical engineers listed high-strength steels and aluminum and magnesium alloys, and the ceramic engineer pointed to studies in high heat-resistant refractory linings.

Almost every engineer mentioned nuclear fission, not so much in terms of the amazing discoveries of the physicists, but rather in terms of the engineering research, the industrial super-marvels in a host of related fields which were necessary to bring into successful operation the stupendous plants at Oak Ridge and at Hanford and the bomb assembly plant at Los Alamos.

Each of the developments noted is a story in itself. Moreover, each is the result of a chain of basic research studies which in some cases extends years into the past.

The development of radar, in other words, radio detection and ranging, is one of the fascinating stories of intense scientific concentration during the war. But though the development of radar is definitely associated with the war, it is a combination of various elements, all of which had their origin in earlier days. The radio-physicist, Heinrich Hertz, in 1887, made the first discovery that radio waves were reflected from objects like light rays, and the second discovery that radio waves could be directed along narrow beams. The third discovery was that distance may be measured accurately by timing the high-speed travel of the radio wave. The fourth was that reflected waves may be detected by wave interference patterns. The fifth was the principle of radio-pulse ranging. Fitting these building blocks together and developing the necessary instrumentation, such as the pulsed microwave magnitron for measuring accurately very short intervals of time, were the ultimate achievements.

We all know how radar saved Great Britain during the war, how Japanese warships were sunk in total darkness by radar-equipped American ships, but the peacetime uses of radar in navigation and in such spectacular applications as ground-controlled plane landings in dense fog with zero ceilings, or in weather fore-

casting are just beginning to attract the attention of laymen.

The amazing developments in the field of nuclear energy which reached fruition during the past decade also had their origins years ago, but in 1905, when Einstein published in a German journal the now world-famous equation which gives the relation between energy and mass, $E = MC^2$, not even he foresaw the train of events leading to that crucial date, December 2, 1942, when the physicist Enrico Fermi finally achieved success in starting a sustained chain reaction and in controlling it in his uranium and graphite pile beneath the concrete bleachers at the University of Chicago.

There were still many problems to be solved after this historical date, but most of them were engineering problems. The successful solution of these problems for war-time purposes culminated in that awesome atomic bomb explosion on July 16, 1945 at Alamagordo, New Mexico. The culmination for such major peacetime purposes as the generation of power from nuclear energy is still in the future, but possibly in the very near future. Experimental power plants will soon be in operation at two laboratories. Concurrently, research has been started on the difficult problem of the disposal of radio-active wastes. This is one of the most challenging researches ever to confront the sanitary engineer.

Man's new knowledge of the atom has brought the world to the threshold of a new era. It has opened up new vistas of research undreamed of 10 years ago, research touching almost every phase of scientific activity. It has highlighted the need for a new kind of engineer—the nuclear engineer. The basic pattern of training for such an engineer is not yet clearly defined, but it will undoubtedly call for graduate study in nuclear physics, superimposed on a fundamental education in science and technology.

It is hardly necessary to focus attention on the complex problems posed for the economist, the sociologist, and the political scientist by the development of atomic energy, a development which must of necessity be under the control of the state. Nuclear fission is "Too hot"; it has too many national and international ramifications to be entrusted to private enterprise. That is why its development has been placed under the control of a Federal Agency, the Atomic Energy Commission.

Transportation and Communication

What lies "beyond the horizon" in the realm of transportation due to the significant developments of the past decade? Only 45 years ago the Wright Brothers left the ground at Kittyhawk in the first successful flight through the air. They flew 120 feet, 10 feet above the ground, at 30 miles per hour. No airport was needed. Two years ago, the Boeing XB-47 Stratojet swept-wing bomber flew from Moses Lake in the State of Washington to Washington, D. C., in a little more than 4 hours at a speed greater than 600 miles per hour. It would never have left the ground, however, without the modern air strip designed by the civil engineer. Other planes have pierced the sonic barrier and now fly faster than the speed of sound and at heights over 50,000 feet above the ground. The V-2 rocket reached an altitude of 114 miles. It streaked through the sky at a speed of over 2000 miles per hour to drop its lethal load of TNT on London. A new Navy rocket has just risen to a point 250 miles above the level of the earth. Is it any wonder that engineers and scientists are talking about rockets to the moon? With rocket engines which do not need air for fuel, with nuclear energy as a source of power, with metals of high strength, with refractory linings of high heat-resistance, with radar as the navigation and communications aid, travel to the moon, 238,000 miles away, does not seem to be a fantastic dream.

Less spectacular in nature will be the terrestrial expansion of superhighways to make our automobile travel safer, faster,

more economical, and more convenient. Billions of dollars will be spent in the next 25 years modernizing the existing 3,000,000 mile network of city and county roads and in creating new transcontinental routes. There will not only be divided lanes, there will also be separate routes reserved solely for passenger cars, traveling between the great metropolitan centers in the densely populated sections of the country. There will be new pavement types.

The field of servo-mechanisms and electronic controls is one that will affect the lives of many of us in future years. Industrial application of servo-mechanisms is still in its infancy, but nevertheless we are already sensing the implications in the development of numerous automatic machines with a concomitant displacement of labor. The resulting social problems are serious, but we must not forget that science and technology, while reducing the labor rolls on one front, are constantly creating new jobs on another front.

Television is a typical example. It has already become an industry of major proportions, offering employment to thousands of people. At the beginning of 1950, 98 stations were broadcasting television programs to about 3,700,000 receiving sets. Sets are now being turned out at the rate of more than a million a year.

What will be the effect of television on education, on movies and drama, on sports, and on the living habits of the nation? At present, there is some belief that television is doing more harm than good. Too many oldsters are spending too much time in front of saloon and tavern receivers; too many youngsters are camping in front of home sets when they should be outside playing baseball and football.

In the realm of education, television is certain to exert a growing influence in coming years. In medical education, the operating theater filled with eager medical students is on its way out, for television now lets every student stand in the center of the stage and look over the surgeon's shoulder at the intricate sequence of a difficult operation.

Electronic computors, digital and analog, are now providing answers to problems hitherto unsoluble in stress analysis, in astronomy, in electrical networks, in mechanical vibrations, in ballistics research. They are being used to explain the behavior of electrons, protons, and neutrons. They are accomplishing in minutes what formerly would have required hundreds of man-years of work with desk calculators.

Will the world of tomorrow be a time-and-motion study world? Will we all button our vests from the bottom up, instead of from the top down, because Frank Gilbreth found that four seconds could be saved. Will we all use two shaving brushes concurrently to save 17 seconds? Will we all take our baths in precisely the same way? It is easy to lampoon the results which Dr. Gilbreth and his equally famous wife, Lillian Gilbreth, have obtained, but we know that their studies and similar researches have lightened the work load for thousands of people in industry. The techniques of this science are now being extended to the field of agriculture, and in the future our farmers will do as much and even more than they are doing today and with much less effort.

Housing is due for a major operation. A substantial, low-cost home that will conform to minimum accepted standards and will have somewhat more individuality than a dog-kennel is the crying need of today. The satisfactory ones are still too expensive. The low-cost ones are too cheap. According to the Twentieth Century Fund Survey, about 15,000,000 new houses will be needed in America by 1960. About 9,000,000 of these are replacements of existing sub-standard, urban and farm dwellings.

The housing needs of America and the world will never be met, however, if we continue to build the majority of houses

in the future in essentially the same way that they were built 30 years ago. We cannot ignore the lessons of other achievements as to the relative values and roles of human energy, animal energy, and mineral energy, yes, even nuclear energy. Machine-age production of artistic homes is on the way. Current and future research, plus the competitive urge inherent in the political and social climate of this country will find the answer to this major problem of low-cost, satisfactory housing.

One could go on indefinitely looking through the rose-colored glasses of science and technology at distant frontiers. But one detects the note of the cynic, "Why don't engineers and scientists take a long vacation? What price glory if it means only the winning of more material comfort for mankind. Is it all worthwhile?"

Of course it's worthwhile! The research engineer and the scientist will never stop. They, like all research workers—in fact, like all human beings—respond inherently to a challenge. They, like all research workers, will continue to accept the challenge that urges them upward and forward on trails that disappear beyond the horizon. They are aware that their achievements will bring to the fore complex social, economic, political, and spiritual problems. But the engineer and the scientist cannot be expected to solve these problems. They must relinquish them to kindred spirits in sociology, economics, political science and law—to experts who will have an appreciation for, and some knowledge of, the nature of science and technology as they seek the answers to these very difficult problems dealing with human nature and behavior.

We all travel together on the trail that has no end—and as we journey together with eyes fixed on distant horizons, let us remember these lines,

He builds his temple on the shifting sands
Who holds no toil worn hand within his own
A portless mariner by fate's wind blown
He wrecks his ship on failure's deadly land.

Who has not high ideals at his command
Knows not creation's joys nor can enthrone
The mind's high majesty, but walks alone
Nor feels the rapture born of work's demand.

Then do the thing which life ordains for thee
For its own sake, and set thy spirit free
From all that holds thee to the lesser thought.
Make of thy task a shrine, and kneeling there
Lift to thine eyes the things thy hand hath wrought,
And in thy soul breathe deep achievement's air.

—Anonymous

Factors and Trends Relating to The Economics of River Developments*

By MERLE E. SUTTON

Assistant Chief Engineer, R. W. Beck and Associates, Seattle, Washington

It is with somewhat mixed feelings that I address you on the subject of River Development. This stems from the fact that, as counselors and advisers to the younger generation of engineers you can and do prepare them for the important decisions which they are to make in the future, and secondly, as engineers you are obviously interested in details and current thoughts pertaining to water resources and their control.

In view of this observation and the limited time available, it seems best to approach the subject from the standpoint of relating the broad factors involved with the hope that the stimuli of discussion and questions raised would be of equal value to the citation of specific problems and their solution. That is to say that "where we are going" is of equal or perhaps more importance than "where we have been."

We all appreciate the fact that natural rivers and waterways are God-given resources which have played an important part in the growth and development of our country. It may also be added, as we will discuss later, these same rivers, by the whims of nature, have produced some of our most aggravating economic problems. Even while many of our larger urban and rural areas have outgrown their early dependence upon the waterways for communication and commerce, their continued growth and prosperity are monuments to the part these waterways have contributed and still do contribute to this growth. This economic status has not been attained without a price having been paid in the form of flood damages. A continuing battle has been waged to prevent these damages and to promote a profit by commerce through navigation on our inland waterways. The benefits have justified the price, but economic complexities have brought into being the modern and concentrated versions of river development.

While this paper has to do with the Economics of River Developments, it cannot hope to discuss in detail all the interrelationships of river development useful to the young engineer, nor can it completely review the scope of all problems associated therewith. However, we can touch upon some of the general aspects of the problem which will aid in keeping our thinking straight. Likewise, a review of recent directive trends in regional river development will indicate some of the economic factors and problems requiring solution and perhaps in so doing will assist in establishing constructive suggestions for the benefit of our over-all economy.

The tools of economic analysis have been variously and quite completely covered in papers and texts available to the engineer and student. What we may not see so clearly, however, are the problems and trends which will require the skillful use of these tools. Then our first attempt should be to establish a theme, less specific in nature than the technical aspects

* Presented before the Committee on Engineering Economy at the 58th Annual Meeting of the ASEE, Seattle, Washington, June 20, 1950.

of the problem, in order to introduce the approach we wish to make. This theme is the human side of engineering—that intangible but real something that makes for leadership and accomplishes the ultimate element in professional service.

The Engineer's Responsibility

It is not enough that the young engineering graduate be armed with a complete set of classic fundamentals which he may polish to varying degrees of brilliance in fields of practical application. His responsibility goes farther and his eventual success depends upon the manner in which the human factors find a place in his equations.

The very nature of the engineer's creative effort involves the welfare and inherent rights of people which must, therefore, be recognized in all situations where these factors exist. In fact, because the results of his efforts affect people in some manner or other and his success is dependent upon how well they are served and made to understand it, the engineer must be able to transmit his thoughts and ideas in common and straightforward terms. He must always be conscious of the resultant social and economic impacts of his work and be guided accordingly. To be sure, the engineer can develop the facility to cope with problems of this nature only after long experience, but the sooner he learns that to do so is a requirement of his profession, the greater will be his value to society. He will also be a happier and more successful man than if he remains a technological hermit and witnesses the products of his creation gravitate into inflexible patterns not subject to or amenable to the greatest good.

Now back to our primary subject. Rivers have not always been obedient servants; they have been unruly in flood, overrunning their banks and dispoiling rich cities and adjacent lands while whimsically changing their channels or filling them with navigational hazards. In other areas, people also have become dependent upon river waters to irrigate the fertile but semi-arid lands isolated by nature. As the National economy expanded, the problems of flood control, navigation, irrigation and industrial power also increased. This is not to say that they did not exist before, but, rather, that they have become more complicated with time; thus affecting the rights and lives of greater numbers of people.

The initial solutions to river problems were largely on a single purpose basis, as for example in regard to flood control, by the building of levees on the Mississippi River and the early flood control dams in Ohio. Perhaps flood control did not mean much to a New England coastal community or to the people who lived along the Florida beaches, for example, but when the rainfall in the Mid-west and the melting snows from the eastern and western mountain chains rose coincidentally in the Mississippi River until the water lapped the tops of the levees, flood control became a reality, and when the levees failed, a tragedy. As the obvious solution to flood control became that of controlling the source—the tributaries—an extension of National responsibility evolved. And so it has been with the other basic problems, such as navigation and irrigation, until now we have the multi-purpose projects in regional river basin development. This is not to say that each project is justified on the basis of navigation, flood control or irrigation, but rather that each regional development may contain projects justified by one or more of these elements. Truly then the National Government, by virtue of its responsibilities, has been placed in a position to develop a great river basin; for navigation, flood control and irrigation are all part of the problem.

We cannot question the evolutionary processes by which this situation has been brought into being, but because the economic development of river resources is essential to National and regional economies the costs of these developments must be paid in one manner or another. Project feasibilities must be supported by

the tangible and intangible economic factors associated therewith and be related one to the other in proportion to the importance ascribed to each. If this be true, and while in itself not providing an inclusive formula for the allocation of project costs to the beneficiary elements, it will at least focus our attention on a starting point. Strictly speaking, each element should be able to stand on its own economic merits within the over-all project justification and bear the spotlight of careful business cost analysis or accountability.

Conflicting Theories of Cost Allocation

Without sound and valid starting points as to the economic factors involved, conflicting interests cannot effectively cooperate to the end that maximum mutual benefits be attained. The problems and economics of river development are not simple nor are they the same in all regions. There can be no positive or definite pattern in connection with a determination of the economics involved in river development because conditions and requirements are not necessarily static nor similar and thus variations must be carefully compromised. Therefore, it is erroneous to assume the same yardstick as applicable in all cases. If this be a valid assumption, then the administration or coordination of a regional development must be sensitive to and largely subordinate to regional requirements. Apparently then, responsibility in river basin development and the multi-purpose projects contained therein is a cooperative partnership; the National Government representing the National interests and the region representing those which are or may become of regional significance and importance.

To the east, the south, the north and to the west the evolutionary process of river development has proceeded—each having its peculiar problems with honest attempts being made to solve each problem in its own particular way. Objectively, this is as it should be. The engineer must be ever conscious of this fact; he must be able to discern those interests or factors which are specific and those which may be in conflict or overlapping and advise accordingly.

We have progressed to considerable lengths in river development from the time in which power generation was considered solely an incident by-product to hydraulic projects, to the present in which power generation has become of major importance in such projects. Hydro-electric power, a younger brother of the multipurpose project and necessarily a product of regional river development, has assumed robust and dominant proportions and must be treated with a respect compatible with its importance. It should also be apparent that most of the hydroelectric energy generated in the future must be from river basin development, as it is inseparably connected with water conservation for all purposes.

In its role of developing river basins to meet navigation, flood and irrigation requirements, the National Government has largely assumed the control of power resources incident thereto. Perhaps this evolutionary process would be more logical if it were not for the fact that Federal administrative agencies oftentimes reflect marked differences in perspective and objectives. Variations in viewpoint and, when coupled with the importance that electric power plays in regional economies, pose critical problems, solutions to which must be found. Let us look at a few of the more general cases.

In the construction of Boulder Dam (Hoover Dam) and the power lines leading to the City of Los Angeles and elsewhere, the financing was so arranged that Los Angeles and other customers of the Boulder Dam system guaranteed repayment, with interest, of the sums expended by the Government for construction. Of course, the people of Los Angeles therefore believe that all publicly owned power projects, wherever built on any of our rivers, should be financed in similar fashion and should be designed

to pay interest on the investment until it has been completely amortized out of plant income.

An entirely different situation exists where dams are built by the Reclamation Bureau for the primary purpose of irrigation and flood control. Power may in some cases be sold at such a price as will permit paying interest on the sums expended for construction of facilities, but the interest goes to assist farmers in the area reclaimed to pay the bill for irrigation and other charges. These dams are of benefit to the areas they serve, both in providing low electric rates and in aiding agriculture, but the money paid in interest subsidizes the farmer. Moreover, the feasibility of the irrigation element is distorted in this type of multi-purpose project.

A typical basin development is the Tennessee Valley in which the Government has built a series of dams for power, flood control and navigation. Federally owned dams and transmission lines provide power to municipalities and cooperatives for distribution. The locally owned distribution systems finance their operations on a self-sustaining basis and pay power rates sufficient to pay T.V.A.'s cost for that part of the expenditure allocated to power, with sufficient margins to pay to the Government the equivalent of interest, certain taxes and to amortize the debt.

A fourth procedure is that where the U. S. Engineers build power plants as a part of river improvement for flood control and navigation.

There seems to be a multitude of variations to these main ideas, and it may be that all of these various arrangements have merit and are justified. Perhaps they are all equitable and each procedure, as is very probable, best adapted to the needs and conditions of the area served. Certainly, if some region in the country is short of water power resources and must, of necessity, produce its electric energy by other means, this would not be a good reason to deny the development of other regions containing river resources. If these water resources are usable and the plan is feasible, there is no reason why they should not be utilized. But, whatever the project—large or small—it should not be for the profit of one section at the expense of the rest of the nation. On the contrary, it should be so developed as to be economical and profitable to the nation as a whole.

Developing of Sound Principles

If there are inequities or injustices, in fairness to all, they should be corrected and only through a strong partnership representing both Federal and regional interests can these problems be searched out and solved. In this concept will reside the basis and assurance of sound planning and the proper evaluation of the economic factors associated with river development to the end that valid justifications need never be questioned. To be successful, something more than formalized public hearings will be required. Rather, it must be a hard-hitting working arrangement capable of making decisions without prejudice to business principles.

Such questions as how should the allocation of costs for flood control, irrigation, navigation and electric power in multi-purpose projects be made so that financing and amortizing of the investment and the costs of operating the facilities will be on a self-liquidating and sustaining basis are not simple. But the fact that it is more economical to serve multi-interests in a common project by no means makes it impossible to determine the share of each in the project. It would be far more difficult to justify the position that the consumers of electric power for example, by their purchases through their own public agencies, are not entitled to the generating and transmission facilities once they have paid the Government in full. This is not a new point of view and its importance will increase with time.

While considerable emphasis has been placed upon Federal river basin development because of its evolutionary and dominant position, regional concern and voice must be representative of both private and public interests involved. This cooperative obligation has been brought into particular prominance by the importance of electric power generation and the desirability of integrating output and transmission through interconnections and power pools. While this example of regional cooperation between Federal, public and private utilities is one of operational procedure and is very advantageous to all parties in obtaining the maximum benefits of generation, it should also focus our attention on the necessity for similar integrated water development.

Complete river basin development implies full and effective utilization of all water resources and because the development boundaries are readily determinable and fall within limits, each successive planned step must recognize the ultimate need. The crux of this statement lies not in the fact, which is appreciated by most of us, but in the trends which may place its accomplishment outside the control of those most intimately affected. Whether water resources are being developed by the National Government, by private enterprise, by States or by lesser public agencies coordinated accomplishment can and must be attained through cooperation—representative cooperation—to assure that all plans and programs are productive of the greatest good and free from dominance.

Let us be certain then that the waters stored in common reservoirs for flood control, irrigation, navigation and power be charged for in proportion to their occupation and use of facilities with annual charges thereafter measured by the bentfits to each. Let us recognize that while the National Government must continue to play an important and perhaps leading part in river basin development, this mission must be accomplished in cooperation with other regional programs and needs without dominance. Then wishful justifications will be out, projects will bear evidence of economic feasibility, and, lastly, peace should reign on the question of what should be done and how it should be done in river basin development.

'Packaged" Unit Operations Laboratory Equipment

By RICHARD STEPHENSON * and GEORGE W. PRECKSHOT
*Assistant Professors of Chemical Engineering,
University of Minnesota*

Summary

A survey of manufacturers and special fabricators was made to determine the availability of "packaged" type unit operations laboratory equipment for use especially in educational institutions. The conventional unit operations laboratory apparatus can be obtained as "packaged" units from the suppliers listed. The more specialized equipment can be procured at higher cost from various manufacturers and special fabricators, some of whom also are listed.

Introduction

Several educational institutions recently have had to purchase unit operations laboratory equipment for new experiments, or to replace that which was worn-out, obsolete, or destroyed. When the number of pieces of new equipment is large, a great deal of staff effort is required for its selection, specification and location of suppliers. As is too often the case, staff members are already working at full capacity and this additional burden presents a serious problem.

General

In order that other staff members faced with the above problem can reduce the work required to locate suitable laboratory equipment, the authors report the result of their survey of the suppliers of "packaged" type unit operations laboratory equipment. It might be well to explain what is meant by a "packaged" unit. Such a unit is defined as a piece of equipment which is ready for operation when connected to the various services; that is electricity, steam, hot or cold water, air, vacuum or drain. If the "packaged" unit is large, it will require reassembly before connection to the services.

The authors have endeavored to include only those units which in their opinion are adaptable to small scale laboratory work. A rather large number of these small "packaged" units are available for the more important unit operations. These require no engineering design on the part of the customer. They are grouped conveniently, according to the unit operation, in the charts which appear with this article. Some manufacturers will fabricate "packaged" units to the customer's specifications. This information is also given in chart form. Extensively detailed information about each unit was purposely omitted in fairness to those manufacturers who did not submit such complete specifications of their equipment. Since the overall dimensions are of vital interest, they are included in most of the charts; some of these are estimates.

Packaged Units

Distillation: Distillation outweighs any of the other unit operations in importance and extent of use. "Packaged" units to perform all types of distillation are available in a wide range of sizes, materials of construction, and prices.

Most of these units are provided with sufficient instrumentation to make them

* Now at Oak Ridge National Laboratories, Oak Ridge, Tennessee.

readily adaptable to laboratory experiments. Several are available with packed columns but the majority of the columns are plate types containing from 15 to 30 bubblecap trays. In general these units may be operated under a vacuum or at moderate pressures. Units are also available for operation at higher pressures. As a rule, manufacturers are prepared to make slight alterations in design to conform to the customer's need. The extent of these alterations, of course, will determine the increase in price above that of a "packaged" unit. Prices range from about $500 for a simple batch unit of copper construction to approximately $10,000 for the most elaborate plate column, also of copper construction. Table I contains the summarized list of manufacturers of distillation units.

Evaporation: Equally as plentiful and versatile as the number of distillation units are the "packaged" evaporator units. Single-, double- or triple-effect evaporators may be purchased at prices ranging from $650 for a Pyrex glass single-effect bench model unit to $11,000 for a large triple-effect unit of steel construction. A versatile double-effect evaporator is pictured in Fig. 1. This evapora-

TABLE I

MANUFACTURERS OF DISTILLATION UNITS

Manufacturer and Address	Column Dimensions		Col. Diam.	Versatility of Operation	Materials of Construction
	Plates	Overall Ht			
Acme Coppersmithing & Machine Co. Oreland, Penna.	20	30′6″	14″	Simple batch distillation, batch and continuous fractionation units.	Copper
				Fractionation unit	
American Copper & Brass Works 612 E. Front St. Cincinnati, Ohio	17	20′0″	8″	Fractionation unit	Copper
Ansonia Copper & Iron Works Cincinnati 4, Ohio	20	15′0″	4″	Simple batch distillation, batch and continuous fractionation unit.	St. S.
	20	14′0″	8″	Fractionation unit	St. S.
	30	12′0″	3″	Fractionation unit	St. S.
Arthur D. Little, Inc. Cambridge, Mass.				Recompression still	
Artisan Metal Products Co. 73 Pond St. Waltham 54, Mass.				Packed column	St. S.
				Fractionation unit	St. S.
Badger Mfg. Co. 260 Bent St. Cambridge, Mass.	15	24′0″	8″	Simple batch distillation, batch and continuous fractionation unit	Copper
Brighton Copper Wks, Inc. Cincinnati, Ohio	20	20′0″	8″	Fractionation unit	Copper
				Simple batch distillation	St. S.

TABLE I—*Continued*

Manufacturer and Address	Column Dimensions		Col. Diam.	Versatility of Operation	Materials of Construction
	Plates	Overall Ht.			
Carter & Nansen Co., Inc. 415 Lexington Ave. New York 17, N. Y.	20	22′0″	12″	Simple batch distillation, batch and continuous fractionation unit	Copper
Cleveland Coppersmithing Works 5500 Stone Ave., N.W. Cleveland, Ohio				30 gal. batch still	St. S.
Emerson Sheuring Martindale Ave. & 21st Indianapolis 7, Ind.					
Pfaudler Co. 111 W. Washington Ave. Chicago 2, Ill.		10′	4″	Packed column fractionation unit 30 gal. simple batch distillation unit	Glass lined steel Glass or St. S.
F. J. Stokes Mach. Co. Tabor Rd. Philadelphia 20, Penna.	15		5″	Simple batch distillation, batch and continuous fractionation unit Vacuum stills	Copper
Struthers-Wells Corp. Warren, Penna.	16	25′	14″	Simple batch distillation, batch and continuous fractionation unit 20 gal. reaction still	St. S. St. S.
Vulcan Copper & Supply Co. Cincinnati, Ohio	24	28′	8″	Simple batch and azeotropic distillation batch Continuous fractionation units	Copper

tor costs about $4470 when of mild steel construction and has a total evaporation capacity of 350–400 lbs. of water per hour.

Evaporation in these units may be carried out as pressures slightly above atmospheric down to a comparatively high vacuum. The types of evaporators, varying in number of effects, included in this listing are: standard, vertical, long tube vertical, forced and natural circulation, vapor recompression, heat pump type, direct fired, and submerged combustion type A photo of the last type is shown in Fig. 2. Most of these units are produced in steel, stainless steel or copper construction. Still other materials of construction may be provided. Supporting members are usually of structural steel and generally a considerable amount of instrumentation is provided. With little additional instrumentation, many of these units can be made to serve satisfactorily for evaporation studies Manufacturers of these "packaged" evaporators are listed in Table II

FIG 1 Double effect evaporator (Courtesy Buflovak Midwest Co)

Crushing and Grinding: Most educational institutions give instruction in crushing and grinding A sufficiently wide variety of small crushing and grinding units are available to provide any laboratory with considerable versatility in this line. Included in this list are the following: jar crushers, crushing rolls, gyratory crushers, wet and dry grinding units, ball, rod, tube and compartment mills, swing sledge mills, drum rollers and tumblers, hammer mills and conical mills. A typical "packaged" unit is the dry grinding unit pictured on Fig. 3. In

addition to making the crushing and grinding units, most of these companies also manufacture classifying and separating equipment. The manufacturers' data are summarized in Table III below.

Filtration: Equipment for filtration studies has more often been designed by the institution staff. However, quite a few "packaged" type filtration units now are available, employing various methods of filtration. It is difficult to evaluate their adaptability to specific laboratory experiments. Usually filter presses have served for filtration experiments in most laboratories, and the possibilities of using rotary, vacuum, pressure leaf filters, etc., would have to be investigated for the individual application. The price range for these units varies from $400 for a small filter press to $5000 for a stainless steel rotary vacuum filter. The manufacturers of filtering equipment are listed in Table IV.

Extraction: The ever-increasing importance of liquid-liquid extraction as a unit operation is reflected by the number of small units now available for use in experimental work. Probably of most in-

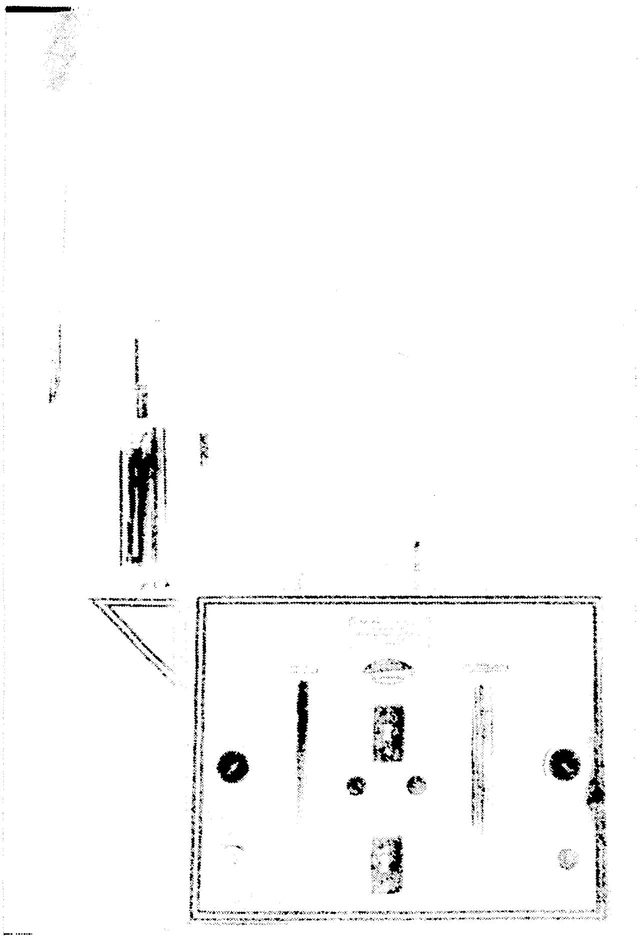


FIG. 2. Submerged combustion evaporator. (Courtesy: Ozark Mahoning Company.)

TABLE II

MANUFACTURERS OF EVAPORATORS

Manufacturer and Address	Approx. Overall Dimens. W × L × H	Type	Materials of Construction
Ansonia Copper & Iron Wks. Cincinnati 4, Ohio	4′ 7′ 9′	Single effect	Copper
Artisan Metal Products Boston 54, Mass.	5′ 12′ 26′	Double effect	St. Steel
Blaw-Knox Co. Pittsburgh, Penna.	4′ 10′ 21′	Single effect	Steel
Buflovak Equip. Co. Buffalo 11, N. Y.	8′ 8′ 12′ 4′ 8′ 12′	Heat pump type and double effect Double effect	Steel and St. S. Steel and St. S.
Goslin-Birmingham Mfg. Co. Birmingham 1, Ala.		Double effect	Steel
Industrial Process Engrs. 8 Lister Ave. Newark, N. J.	4′ 7′ 8′	Single effect Single effect	St. S. St. S.
Arthur D. Little, Inc. Cambridge, Mass.		Vapor recompression	
Mojonnier Bros. Co. 4601 West Ohio St. Chicago 44, Ill.		Standard single and multiple effect and heat pump type	St. S.
Ozark Mahoning Company Tulsa, Oklahoma	25″ 42″ 56″	Submerged combustion	St. S.
The Pfaudler Co. 11 W. Washington Ave. Chicago 2, Ill.	28″ I.D. 10″ depth	Single effect Evaporating pans	St. S. Glass lined steel
F. J. Stokes Mach. Co. Philadelphia 20, Pa.		Double effect	Cast iron, Copper
Struthers-Wells Corp. Warren, Penna.	8′ 15′ 11′ 1′ 3′ 4′	Triple effect Single effect	Steel Pyrex glass
Swenson Evaporator Co. Harvey, Ill.	6′ 14′ 21′	Double effect	
Vulcan Copper & Supply Co. 120 Sycamore St. Cincinnati 2, Ohio	2 single effect evaporator units are available		
Struthers Wells Corp. Warren, Penna.	7′ 8′ 11′ 8′ 11′ 11′	Single effect Double effect	Steel Steel

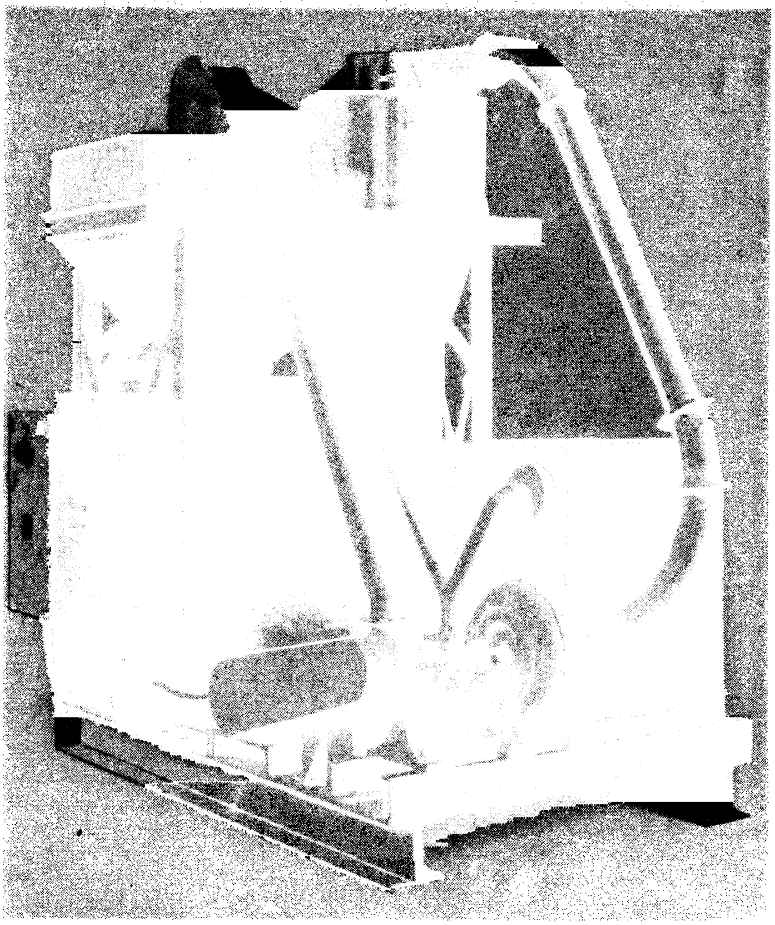


FIG. 3. Dry grinding Unit. (Courtesy: Hardinge Company.)

terest are the counter-current extraction columns of which several types are offered. These are, as a rule, constructed of Pyrex glass or stainless steel. Extraction columns, complete with accessories, range in price from $700 to about $3000. Manufacturers of these "packaged" type liquid-liquid extraction units are listed in Table V below.

Drying: Normally some sort of drying equipment is required for institutional laboratories for unit operations or for other uses. Included in this group of equipment are spray, drum, adsorption and absorption, tray and vacuum dryers, their use dictated by the type of laboratory experiment desired. The price of these units varies from $150 for the small adsorption type of air drier, to $4500 for a larger tray type drier. Table VI is a collection of information for "packaged" type driers.

Heat Transfer: Generally, equipment designed to illustrate heat transfer in the unit operations laboratory is a special problem that must be handled by the individual staff. However, there are a number of firms who manufacture heat exchangers and who are in a position to fabricate such equipment on the basis

TABLE III

MANUFACTURERS OF CRUSHING AND GRINDING UNITS

Manufacturer & Address	Type of Equipment
Abbe Engineering Co. 50 Church St. New York 7, N. Y.	Jar mills, jar rolling machines, pebble and ball mills
Allis-Chalmers Mfg. Co. Milwaukee 1, Wis.	Crushing rolls, jaw crushers
American Pulverizer Co. St. Louis 10, Mo.	Hammermills, crushers, shredders
Bauer Bros. Co. Springfield, Ohio	Grinding mills
Hardinge Co., Inc. 240 Arch St. York, Penna.	Wet grinding mills, conical dry grinding mills
Patterson Foundry & Mach. Co. East Liverpool, Ohio	Wet and dry grinding equipment, ball mills, jar mills, crushers
Sprout-Waldron & Co., Inc. Muncy, Penna.	Attrition mills, hammer mills, roller mills, crushers, grinders
Sturtevant Mill Co. Park & Clayton St. Dorchester, Boston 22, Mass.	Rolls, jaw crusher, crushing rolls, grinder, swing sledge mill, coal crusher
Traylor Engr. & Mfg. Co. Allentown, Penna.	Jaw crushers, gyratory crushers, crushing rolls, ball, rod, tube and compartment mills.
Troy Engine & Machinery Co.	High speed three roll mills
U. S. Stoneware Akron 9, Ohio	Jar mills, ball mills, drum rollers and tumblers

of the customer's specifications. These are listed below in Table VII.

Other Unit Operations: Not all of the unit operations are illustrated in experiments in every laboratory. Gas absorption, crystallization and leaching are those which may not be illustrated. "Packaged" units are available for these as well. The Struthers-Wells Corporation, Warren, Pennsylvania, manufactures an absorption column having an outside diameter of 14 inches containing 12 bubble-cap trays. The overall dimensions of this unit are 2 feet by 2 feet by 22 feet. Another unit is made by Carter & Nansen Company, Inc., 415 Lexington Ave., New York 17, New York, but the authors do not have the specifications for their equipment.

For crystallization studies an evaporative type unit is available from the Swenson Evaporator Company, Harvey, Illinois. This unit is constructed from stainless steel and the overall dimensions are 3 feet by 8 feet by 10 feet. In addition, a Swenson-Walker type continuous crystallizer can be obtained from the above manufacturers.

The Dorr Company, 221 North LaSalle St., Chicago, Illinois, manufactures a bench model countercurrent decantation unit which can serve for an experiment in leaching. A photo of this unit is shown in Fig. 4.

Special Unit Operations Equipment: Often special characteristics are required in unit operations equipment, and it may not be possible to incorporate them in any of the standard "packaged" units already available. Manufacturers of industrial equipment who ordinarily do not construct small units, are willing to construct such units from a design drawing and/or sketches submitted by the customer. These companies are listed below in Table VIII and are in addition to those listed in previous tables. In general, manufacturers of standard "packaged" unit type of equipment mentioned in previous Tables are also prepared to fabricate such units according to the customer's specifications.

Other Sources of Unit Operations Equipment

Sometimes a limited budget may call for the purchase of used but serviceable equipment. Often new equipment is not essential. The present survey indicates that R Gelb & Sons, Inc., State Highway No. 29, Union, New Jersey and First Machinery Corporation, 157 Hudson St., New York 13, New York, can provide such serviceable equipment. However, care must be taken in the selection of units having sufficiently small capacity. The authors are aware that the survey of used equipment suppliers is by no means complete.

TABLE IV

MANUFACTURERS OF FILTRATION UNITS

Manufacturer and Address	Filtering Area	Materials of Constr.	Overall Dimens	Type of Unit
Alsop Engrg. Corp. Milldale, Conn.				Disc pak filters
Eimco Corp. Salt Lake City, Utah	4 ft.^{2}	St. S.	3′ × 5′ × 5′	Vacuum filter
Filtration Engrs., Inc. 155 Oraton St. Newark 4, N. J.	3 ft.^{2}	St. S.		Rotary vacuum filter
Hercules Filter Corp. 204–208 21st Ave. Paterson 3, N. J.	½ ft.^{2}	Bronze nickel or St. S.		Pressure leaf filter Sheet filters
J. Shriver & Co., Inc. 808–864 Hamilton St. Harrison, N. J.	5.7 ft.^{2} 5.0 ft.^{2}	Monel metal Monel metal		Filter press Filter press
Tite Flex Inc. 500 Trelmghuysen Ave. Newark 5, N. J.	½ ft.^{2}	St. S.	7″ × 11″ × 21″	
First Machinery Corp. 157 Hudson St. N. Y. 13, N. Y.				Many types available

TABLE V

MANUFACTURERS OF EXTRACTION UNITS

Manufacturer and Address	Capacity	Overall Dimens. W × L × H	Matr. of Constr.	Type
Artisan Metal Products, Inc. 73 Pond St. Waltham 54, Mass.		2′ 3′ 7′ 2′ 3′ 7′	 St. S.	Soxhlet extractor Extraction tower
Brighton Copper Wks. Cincinnati, Ohio			Copper	
The Pfaudler Co. 111 W. Wash. Ave. Chicago 2, Ill.	10 gal.		St. S.	Soxhlet extraction
Podbielniak, Inc. 341 E. Ohio St. Chicago, Ill.	500 cc./min.	22″ 19″ 21″	St. S.	Centrifugal solvent extractor
F. J. Stokes Mach. Co. Tabor Rd. Philadelphia 20, Pa.				Vacuum extractor
Vulcan Copper & Supply Co. 120 Sycamore St. Cincinnati 2, Ohio				Liq.-liq. and liq-solid extraction units
Otto H. York Co., Inc. 364 Glenwood Ave. E. Orange, N. J.	10 gal. 7 gal.	1′ 2′ 9′ 2′ 3′ 9′	Pyrex glass Pyrex, St. S.	Liq-liq. column Scheibel tower

Conclusions

The authors have consulted the Chemical Engineering catalog as a primary source of "packaged" type equipment for use in Unit Operations laboratories, especially in educational institutions. These units are just as useful for small scale industrial operation. Manufacturers have been listed according to the particular unit operation and pertinent data, in so far as was available was also listed.

If the specifications for a preferred unit were greatly different from those of the standard "packaged" unit, the authors found that the cost was nearly double that of the standard unit. It is suggested that "packaged" units be purchased and later modified into the preferred units by the addition of such standard items as are necessary. In this way both staff effort and cost can be reduced.

The suppliers listed in the charts will fabricate to specifications or drawings and/or sketches supplied by the customer. Needless to say, the cost is lower when detailed specifications and drawings are supplied.

Acknowledgment

The authors wish to acknowledge the assistance of Mr. Wallis Lloyd in the preparation of the tables and manuscript. They are indebted to the respective companies for the information and photographs of the "packaged" units, to the Information Services of the American

TABLE VI

MANUFACTURERS OF DRYERS

Manufacturer and Address	Type	Materials
Artisan Metal Products, Inc. 73 Pound St. Waltham 54, Mass.	Work done to specifications	Stainless steel
Bowen Engrg., Inc. North Branch, N. J.	Spray dryer (50–500 cc./min.)	Stainless steel
Blaw-Knox Co. Pittsburgh, Penna.	Rotary vacuum dryer	
Buflovak Equip. Co. Buffalo 11, N. Y.	Double drum dryer	Cast iron, sheet steel
Davison Chem. Corp. Baltimore 3, Md.	(50–150 c.f.m.) Silica gel air dryer	Aluminum
Despatch Oven Co. Minneapolis 14, Minn. (619 S. E. 8th St.)	Tray dryers	Any material
R. Gelb & Sons, Inc. State Highway No. 29, Union, N. J.	Vacuum drum dryers	
C. M. Kemp Mfg. Co., Inc. 405–15 E. Oliver St. Baltimore 2, Md.	Air, gases, liquids	
National Drying Machinery Co. 2709 N. Hancock St. Philadelphia, Penna.		
Niro Corporation 98 Franklin St. Bloomfield, N. J.	Spray dryer	Stainless steel
Pittsburgh Lectrodryer Corp. P.O. Box 1766 Pittsburgh 30, Penna.	Air dryers (100 ft.^{3}/hr.)	Stainless steel
Proctor & Schwartz, Inc. 7th St. & Tabor Rd. Philadelphia 20, Penna.	Tray dryers	Iron and steel
Selas Corp. of American Erie Ave. & D. St. Philadelphia, Penna.	(50–150 c.f.m.) Silica gel dehydrators	Stainless steel
F. J. Stokes Mach. Co. Tabor Rd., Phila. 20, Pa.	Sublimation dryer	
Swenson Evaporator Co. Harvey, Ill.	5–25 lb./hr. Spray dryer	Stainless steel

TABLE VII

MANUFACTURERS OF HEAT EXCHANGERS

Andale Co.
Philadelphia, Penna.

Artisan Metal Products, Inc.
73 Pond Street
Waltham 54, Mass.

Brighton Copper Works, Inc.
2144–2160 Colrain Ave.
Cincinnati 14, Ohio

Doyle Roth Co.
Newark 5, N. J.

Graham Mfg. Co , Inc.
415 Lexington Ave.
New York 17, N. Y.

The National Radiator Co.
221 Central Avenue
Johnstown, Penna.

Patterson-Kelley Co., Inc.
East Stroudsburg, Penna.

The Pfaudler Co.
111 W. Washington Street
Chicago 2, Ill.

Struthers-Wells Corp.
Warren, Penna.

Zaremba Co.
Buffalo 2, N. Y.

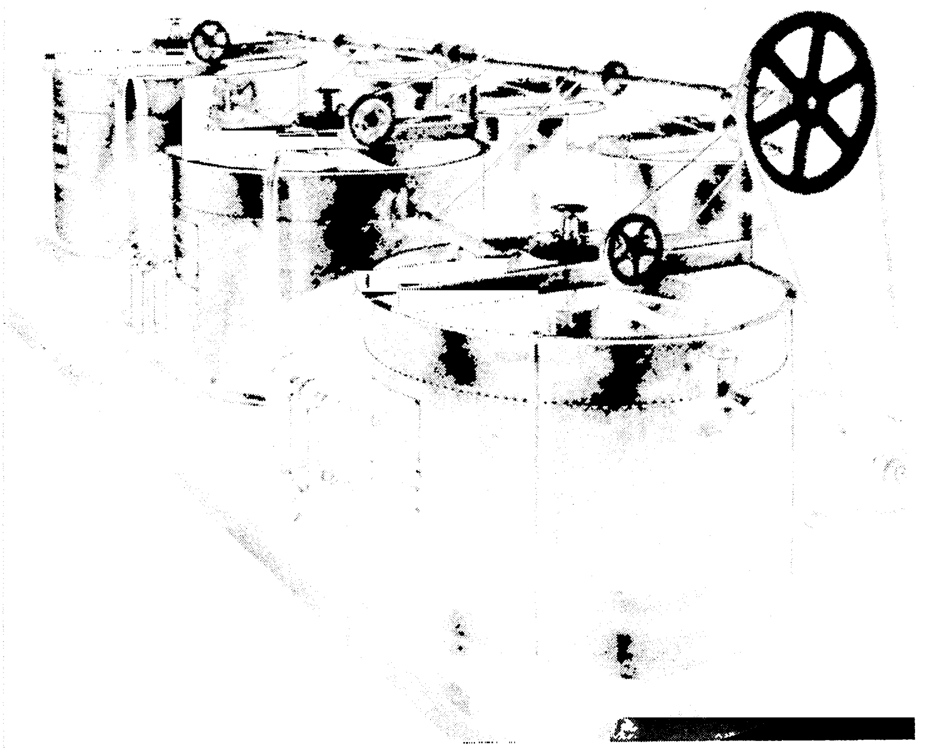


FIG. 4. Counter-current decantation unit. (Courtesy: Dorr Company.)

TABLE VIII

MANUFACTURERS OF SPECIAL UNIT OPERATIONS EQUIPMENT

Acme Coppersmithing & Mach. Co.
Oreland, Penna.

Alloy Fabricators, Inc.
Perth Amboy, N. J.

S. Blickman, Inc.
702 Gregory Ave.
Weehawken, N. J.

Emerson-Scheuring Co.
Martindale Ave., at 21st
Indianapolis 7, Indiana

Farwell, Ozmun & Kirk Co.
Kellogg Blvd. & Jackson
St. Paul, Minn.

Stainless Steel Products
1000 Berry Ave.
St. Paul, Minn.

L. O. Koven & Brother, Inc.
154 Ogden Ave.
Jersey City 7, N. J.

Patterson-Kelley Co., Inc.
East Stroudsburg, Penna.

John Van Range Co.
422 Eggleston Ave.
Cincinnati, Ohio

Chemical Society and the American Institute of Chemical Engineers, and to the Wigton-Abbott Corporation for furnishing information for this paper.

BIBLIOGRAPHY

Chemical Engineering Catalog, 33rd Annual Edition, 1948–49, Reinhold Publishing Corp.

General Objectives of the Engineering Program from the Standpoint of the Evening Graduate Program

By ROBERT W. VAN HOUTEN
President of Newark College of Engineering

In discussing this topic it should be kept in mind that some subjects are primarily of direct benefit to the individual student—who is very probably an employee of industry and through whom industry may indirectly benefit—and others are of primary and direct benefit to industry. In order to serve industry, indirectly and directly on the graduate level, some courses may lead through a formal program to the Master's or Doctor's degree, while others may be part of a non-credit program on the graduate level.

Background of Students

The first topic of importance which should be examined briefly is the composition of the group for whom these evening engineering graduate programs are offered and which can roughly be considered to consist of three general student categories. First of all, not necessarily in order of importance but undoubtedly first quantitatively, are those young graduates who completed their undergraduate studies during the day and who accepted employment after graduation instead of beginning their graduate work on a full-time basis. Some of these men may have been forced to do so because of economic conditions. Personal or family finances may have been such that they deemed it necessary to obtain employment after completing their baccalaureate programs. Others may have decided that it was advisable to accept an exceptional employment opportunity at graduation rather than to risk the possibility of locating as attractive a position a year or two later. It is easy to understand how the student graduating in 1948 or 1949 might have viewed this situation in the light of what he may have heard would probably be the employment situation in, for example, 1950, and possibly 1951.

Among former day students are some who, after four years of formal instruction, welcomed freedom from academic studies but who after two or three years in industry realize the importance of further study on the graduate level. These men are, in general, not in a position to forfeit their positions in industry. They have a certain amount of seniority, their salaries have begun to reflect three or more years of employment, and many of them have undoubtedly assumed family responsibilities. The only course open to them is graduate study in the evening.

A second general group is, of course, composed of those men who earned their undergraduate degrees through evening study. Their situation is parallel to that of the group just discussed but is, of course, even more seriously affected by such factors as seniority, company advancement, financial obligations, and family responsibilities. These men, with rare exceptions, must, if they wish to continue their education, do so during the evening hours.

Finally, there is a third group—possibly the smallest of the three but, nevertheless, important—composed of those employees who lack a formal undergraduate education but who, through

personal study and industrial experience in a specific field, need further training on the graduate level. They are not candidates for advanced degrees but do compose a group for whom the evening engineering college should render service, either by admitting them as auditors to selected courses for which they have adequate prerequisite knowledge, or to noncredit courses on the graduate level. For example, an individual could lack an undergraduate degree in engineering but could have sufficient knowledge and experience in, let us say, the field of metallurgy to profit from advanced instruction in this field.

Academic Standards of Evening Courses

Next, what of this group of young people as a whole for whom evening graduate instruction is offered?

There are those who have had little or no experience with evening programs who contend that evening students cannot maintain the same standards of performance as day students, or they argue that, if the evening student attempts to maintain high standards, his day work suffers.

Those of us who have had considerable experience with evening programs know this not to be the case. Evening courses attract ambitious employees who want to advance themselves, and on the graduate level you find, in general, students of superior ability who are intensely interested in furthering their education in their specific field of interest and/or employment. The contention that the day work of the evening student suffers is also fallacious, as it assumes that the worker who is not studying evenings reports to work fresher than his studious counterpart. As a matter of fact, the student who is devoting some of his evenings to graduate study may be a much better employee and in better physical condition when he reports to work. Moreover, the evening graduate student brings to his courses an educational background and industrial experience which results in a greater appreciation on his part of the subject matter presented, and which permits a sharing of experiences with other members of his class to the mutual benefit of all. Furthermore, because employees in the industrial areas, in which most colleges offering evening work are located, are recruited from many colleges, you find in evening graduate programs students with a wider variety of educational experiences than is found in the average day program. In our evening graduate division, which is comparatively new and which this year has about 400 students, we have, in addition to our own graduates, 68 colleges represented, including McGill University and the Ecole Polytechnique of Montreal. This diversity of collegiate background makes for a much broader viewpoint and more comprehensive discussion in the classroom.

Finally, the evening graduate program can present, as lecturers, specialists, practicing engineers, research experts, operating executives, etc., who are not, in general, available for daytime courses. So much for those who are to be served by the evening graduate program and what this program can offer them.

What Industry Expects

Next, what, in general, is industry expecting of the young engineering graduate, both with respect to his undergraduate education, and his further training? Industry is, in general, asking that graduates be grounded in the fundamentals, with the very specialized training being left in the hands of industry. This is, I believe, as it should be, though we always seem to be faced with a constant struggle to obtain an appreciation on the part of some individuals that a thorough grounding in fundamentals is far more important than an attempt to cover less thoroughly a wide range of subject matter. Industry, by and large, unquestionably prefers the student well versed in fundamentals to one who has covered many subjects somewhat less rigorously.

In addition to such specialized training as industry may give the young graduate in its own programs, it would also appear desirable that the student taking graduate work possess the following:

1. A more comprehensive background of knowledge than is generally expected of the undergraduate student.
2. Familiarity with problems involving more advanced techniques than are taught the undergraduate student.
3 Versatility in knowledge techniques permitting a flexibility on the part of the employer and student which will be of benefit to both.
4. Acquisition of a deeper insight into technical problems from the point of view of the industry and its relation to pure science on the one hand, and the consumer on the other.

In a limited number of cases there is a demand on the part of the student and industry for study on the pure research level.

In discussing graduate training, let me inject one word of caution to the effect that, with all that has been said about graduate education, it cannot of itself counteract personality and character weaknesses. It can render service in the areas indicated but it cannot change the character of the individual who may be technically proficient, but, from the standpoint of personality, a total loss to industry. Great teachers may have a profound effect on an individual of that type, but additional formal education per se will very likely effect no change.

Objectives of an Evening Graduate Program

Now having considered briefly the individuals to be served and what industry expects of the young engineer, we next come logically to the question of what should be the objectives and philosophy of the evening graduate program. Fundamentally they should be the same as that of a sound day graduate program; namely, the education of the whole man, a good general technical education, and a flexibility regarding specialization. I am a firm believer in the necessity for as broad an education as we can possibly offer in the field of engineering. That has long been the fundamental philosophy of our undergraduate program. It was developed under the leadership of Dr. Cullimore, who came to Newark College of Engineering in 1920, and that same philosophy has been carried over into our graduate program.

The principle of a good general technical education beyond the undergraduate level is undoubtedly accepted without question. Very specialized training should be delegated to industry, and, to some extent, to work on the doctoral level. The third factor, flexibility, is important for at least two reasons. First, it permits a broader education and, secondly, it gives the student an opportunity to study in some field other than that in which he did his undergraduate work. For example, a student who received his Bachelor of Science degree in Mechanical Engineering may, because of his present employment, or interest, wish to do his graduate work in Management Engineering. This opportunity should be available to him in the graduate program. Maintaining flexibility is, I believe, extremely important. You will probably recall that, at the Troy meeting last June, the statement was made that "on the average more than 20 per cent of the men graduating in one branch of engineering find employment in another." This statement serves to strengthen further my conviction that undergraduate education should stress fundamentals and the graduate study should continue to develop the whole man, advance his general technical education and, at the same time, provide a program which is flexible.

Finally, with respect to curricula, let me emphasize the importance of continuous attention to a study of the cur-

ricula so that they may meet current and future needs of the student and industry. They should never be static, but, when I say that, I do not mean to imply that they should be subject to the whims of individuals who may be intensely interested in specialities which serve no general or useful purpose and do not fall within the scope of graduate education. Neither should the curricula be subject to pressure groups who may promise financial support, gifts of equipment, etc., as inducements to introduce into graduate curricula subjects of restricted value which have no place within the broad philosophy of the graduate program.

Having said that, however, let me add that specific courses of the type to which I have just referred may justly be given within the scope of a non-credit program and, as a matter of fact, could, and probably should be, coordinated with the specific training programs of industry.

Problems of Financing Programs

Before concluding this talk I do want to comment on the matter of financing the several types of graduate subjects offered. First, at one extreme, is the type of subject which is of primary value to the student and which should be paid for by the student.

At the other extreme are other subjects, probably non-credit, which are basically of value to a specific group of industries rather than to the individual student. These, it seems to me, should be financed by industry rather than the student. As a matter of fact, during the war we had an example of this type of financial support through the medium of the ESMWT programs. While the government, rather than industry, was subsidizing the program, it was doing so in order to make it attractive for individuals to upgrade themselves and thus increase their value to their country through greater service to industry.

Between these two extremes there are also other subjects which are of benefit to the student and industry both and which should receive mutual support from both the student and industry.

There is another factor in the problem of financing graduate programs on which I have not commented and that is with respect to the extent to which public and private colleges should subsidize graduate work from public appropriations or private endowments. This is, of course, of considerable importance and the determination of the extent of any subsidy is a matter for each individual institution to decide, within the scope of the philosophy of its governing body.

There is one point concerning tuition charges on which I should like to comment, and that is with respect to the practice of charging for subjects by the credit-hour rather than by the contact-hour. We do it ourselves, but it does not make sense to me. For example, assuming a tuition charge of $15 per credit-hour, we find that a three credit course, such as Mathematical Statistics (3 class hours per week), carries a total tuition charge of $45, while a six credit course, for example, Advanced Unit Operations (3 hours of lecture and 6 hours of laboratory period), would rate a tuition charge of only $90. In the second case we are giving three times as much instruction for only twice the tuition. In addition, it probably costs as much or more for the laboratory subject if instruction is going to be of the same caliber as the lectures and if the cost of special materials is included. I realize that the rates can be averaged so that theoretically the college does not lose, but, in so doing, it seems to me that the student taking a lecture course is carrying some of the financial burden of the student taking laboratory work. It would appear to me that the only fair basis for tuition charges is the contact-hour rather than the credit-hour. We do this in our undergraduate program, and I hope that we can make the change in our graduate division before too long.

Perhaps I should touch upon the sub-

ject of research, but, because of time limitations and because of the broader aspects of the graduate program, which are probably of more general concern and interest, I am going to say only a word or two. I do want to inject a word of caution to the effect that the colleges carefully consider the type of research projects undertaken. They should certainly be of general interest and should not involve research solely of value to a specific industry or company at public expense. A public institution must be particularly careful not to compete with private research laboratories which are contributing to the support of the public institution through the payment of taxes.

I am convinced that there will be an increasing demand for graduate courses and that the colleges offering evening graduate programs are in a particularly fortunate position in that they have not only a responsibility, but also an exceptional opportunity to serve students and industry by offering evening programs which will meet the needs of both.

Objectives of a Program of Engineering Education in Evening Classes*

(From the Undergraduate and Non-Credit Standpoint)

By HAROLD TORGERSEN

Assistant Dean In Charge of Evening Division, College of Engineering, New York University

A program of evening classes in engineering should be considered in two parts. There seems to be a need for a regular undergraduate program leading to a degree and for a program of noncredit courses. In this presentation the regular undergraduate program will be considered first and the non-credit program second.

The general objectives of the regular undergraduate program offered in the evening should not be different from the objectives of any regular undergraduate program. These objectives, it seems to me, are two-fold. Primarily, the purpose of our undergraduate program in engineering, or in any other field, should be the general education of a student. The program should be organized to develop the intelligence of the individual student. This development should include a rigorous discipline in analytical thinking as well as a development of the social consciousness (and if possible the social conscience) of the individual student.

The second objective of a program of engineering studies should be to provide some measure of vocational training for the student. The details of the portion of the curriculum to be devoted to vocational training of necessity will differ in different institutions. Whatever the details of the curriculum, certain special problems and opportunities arise when the students are employed full-time in business or in industry, as they are when enrolled in an evening program. I do not believe, however, that these problems and opportunities should be permitted to cause any basic modification of the cur-

* Presented before the Evening Engineering Division at the Annual Meeting of the ASEE, Seattle, Washington, June 21, 1950.

riculum which would make it fundamentally different from a regular four-year day program.

While maintaining in the evening program the same basic curriculum which seems proper for a full-time day course, it is desirable to recognize that students who are employed in industry often have a background of experience which can be utilized to advantage by their teachers, particularly in advanced courses. This necessitates a modification of the presentation in some courses if the students are to make the best use of the time they devote to such courses. It is possible to cite from our experience at New York University numerous examples of this.

In our courses in Time and Motion Study we have found it possible to have students in the evening division bring in problems or projects from their places of employment and to use these effectively for class analysis and study. In our courses in Technical Writing we have found that many of the students in the evening division can work on topics directly related to their jobs in industry.

While in general the student who is employed in industry while he is attending college finds his industrial experience helpful in his college work, occasionally difficulties arise because of such experience. Some students become over-anxious to complete the specialized courses directly related to their jobs and try to avoid taking a well balanced program. This tendency must be resisted firmly by those responsible for the administration of the college program.

Turning now to the field of non-credit courses, we are confronted with a program whose basic philosophy is quite different from that of the regular courses leading to a degree. Such courses are bound to be of a rather narrowly specialized nature. Their primary purpose is to supply information and their value in raising the intellectual abilities of the students who take them is, in my opinion, very dubious. In my opinion, any program of non-credit courses should be segregated carefully from the program of courses leading to a degree.

The need for non-credit courses arises from the desire of local industries for men with specialized training, generally of a sub-professional level. Before undertaking to offer such courses a college or university should make a careful study of the matter in collaboration with the industries concerned. Often it will be found that as a result of such a study a well coordinated group of courses can be developed. For some of the students preparatory courses will be found desirable. These generally can be worked out to serve several groups of students.

Our experience in this field has led to the development of a two-year program in Mechanical Equipment of Buildings, including courses in Heating, Ventilating and Air Conditioning and to a program in Building Construction and Estimating. These courses are administered by the Division of General Education of the University and carry no college credit. Some members of the faculty of engineering serve in an advisory capacity in planning these programs. In general, however, the instructors are drawn from industry.

To sum up, then, the objectives of a program of engineering education in the evening should be to meet the needs of the area served by an engineering college. For some students a regular degree program will be found desirable. For others, an array of specialized non-credit courses will better meet the need.

What Program for the Young Instructor?

By FRANK KEREKES

Assistant Dean and Professor of Civil Engineering, Iowa State College

The young instructor should be prepared to assume increased responsibilities as the opportunities arise. In anticipation of reasonable and steady advancement, he needs, first to think through and to determine the objectives he wishes to achieve during his career as an engineering educator. Then, he should plan a program that will systematically lead toward the goals he has set for himself. The formulation of these objectives and the achievement of the program are dependent upon controllable personal factors and upon imposed external factors. The controllable personal factors depend primarily upon the ability, energy and determination of the young instructor; the imposed external factors are established by the precedents and policies of the institution where he teaches. In any case the young engineering educator who wants to be successful in his work has to pursue and to assume a threefold objective and responsibility: he must become a good engineer; he must become an effective teacher; and, he must become an inspiring leader of students and men. Each young instructor will need to develop objectives and program in terms of his own interests and abilities. The following discussion should serve primarily as source material from which each person may select those suggestions which apply to his case and desire.

Becoming a Good Engineer

The young teacher brings to his classes a certain amount of technical skill gained from his engineering studies, his part time summer work, and his practical experience for one or more years with an industry, the government, a contractor, or an engineering firm. In general, many engineering educators have had only a few consecutive years of practical experience. Most of these occurred in the few years immediately following graduation from an engineering school. Occasionally, however, one will find eminent teachers who have become associated with engineering education after a reasonably long and successful career in engineering practice. In a number of instances teachers have taken a year's sabbatical leave; in some others, a few have actually discontinued their teaching connections to enter engineering practice for about two or three years and, then, to return to the teaching field, usually at some other institution.

In reasonably normal times teachers may take advantage of their nine- or ten-month academic year to find engineering employment during the summer months. Thus, a teacher can accumulate one year of profitable, diversified and practical experience during intervals of four to five years of teaching. Diversification can be obtained either by changing employers every second or third summer or by getting opportunity to do more responsible work each summer, at the same place of employment. During the early years of teaching these summer jobs offer welcome changes from class room responsibilities and excellent opportunities for extending one's engineering skill and professional acquaintances. These experiences and friendships become very helpful

* Presented before the Civil Engineering Division, at the Annual Meeting, Seattle, Washington, June 20, 1950.

in the later years of one's teaching, not only as a means of keeping in touch with engineering developments but also in making contacts for the employment of graduates. These associations are of mutual advantage to the employer who needs new recruits from recent engineering graduates. He gains first hand knowledge of the teacher's technical ability and professional attitudes and, therefore, he has more confidence in the students trained by teachers who have worked for him.

The records of many eminent teachers of engineering selected at random from among recipients of the Lamme and Westinghouse awards illustrate the large variation in the time devoted to gaining practical experience. The young teacher of engineering needs to apply foresight, initiative, courage and determination to make the effort and investment required to gain indispensable and essential practical experience that will enable him to become a good engineer.

"Becoming a good engineer" is an important phase of the young instructor's program throughout his teaching career. If, at any time, he stops the processes of becoming a good engineer he also stops being a good teacher of engineering. Memberships in professional engineering societies offer the medium in which the teacher may continue to grow as an engineer, both technically and professionally. The young instructor should make it a MUST, an important part of his program, to join at least three societies: the statewide engineering society whose membership is available to engineers in all branches of practice; one major national technical society which represents his broad engineering interest such as civil, chemical, electrical, or mechanical engineering, or other similar groups; and the American Society for Engineering Education which provides opportunities for development as a teacher through published articles in the Journal of Engineering Education, through committee work in one of the Divisions and through the presentation of papers at Sectional and National meetings. Later as the teacher's interest narrows down to a preferred specialty he will apply for membership in additional technical societies which devote their entire attention to specialized fields such as the American Concrete Institute, the American Water Works Association, The American Society of Heating and Ventilating Engineers, The Institute of Radio Engineers, The American Management Associations and others too numerous to mention. Nevertheless, the engineering teacher should consciously maintain a broad as well as specialized attitude toward engineering practice and education.

Memberships in these societies imply energy and time-consuming responsibilities if they are to play an important role in the development of the young instructor into a good engineer, a good teacher and a good citizen. In the early years the most he can do will be to study those articles which have an immediate and direct bearing upon the courses he is teaching and the courses he would like to teach in the future. He should scan each issue of the regular publications in order to be aware of the problems of his professional group and their relations with the public. The contacts with his statewide society will keep him informed about the local professional, social, economic and legislative problems of his engineering associates. The regular issues of the Journal of Engineering Education will provide him with many ideas for self-improvement in teaching methods and educational practice and policies. Above all he will begin to build up an acquaintance and an appraisal of the men who are actively contributing to engineering technique and education. Then when he goes to the annual meetings of the societies with which he has previously established a paper acquaintance he will speak on more intimate terms with the men whose names he found in the regular publications. He will be able to discuss with them briefly but effectively some portion of their published paper or article. He will make acquaint-

ances that will grow into lifelong friendships.

As the young instructor grows in professional stature he will submit written discussions to major papers in his special field. The stimulation he has received from his society membership will encourage him to attempt an original paper on a subject to which he has given considerable thought and time. Or, he may impress his associates with his judicial attitudes and administrative aptitudes. Then he will find that he is appointed to a committee dealing either with technical problems or society affairs. His associates will recognize his qualities of leadership and elect him at first, to minor offices, and gradually, on his ability to get results he will find himself holding offices of major responsibility. Yes, by getting an early start, by working continuously and effectively, he will find that after ten or twenty years he has become one of those good engineers who used to inspire him when he was a young instructor. The achievement of an objective to become a good engineer has been consummated by steady, intelligent and sincere adherence to a well planned program.

Becoming an Effective Teacher

Experience in engineering practice enhances the potential effectiveness of the teacher and the spontaneous respect of his associates as well as his students. Having successfully coped with the challenge of practical engineering problems, processes and situations, the teacher is in an authoritative position to select practical applications wisely, to employ engineering knowledge and approach naturally, to evaluate the engineering judgment of students accurately, to introduce practical experiences vividly, and to create professional attitudes realistically. These qualifications of the good engineer supply the essential professional ingredients of good teaching.

Evidence points to the conclusion that in the future, as in the past, the engineering teacher will have to acquire teaching techniques, the art and science of teaching, and operational teaching functions after his employment on the staff of an engineering school. This places a responsibility on the teacher to plan for his self-improvement. Furthermore, the head of the department should counsel the young instructor in the planning of a program for professional progress and educational effectiveness. The administrative officers of the college should formulate and support policies whereby the program of the teacher may be achieved.

At first the young instructor will be very busy clarifying in his own mind the fundamental concepts and the essential subject matter of the courses he teaches. He quickly perceives the wide gap between his former student attitude toward learning and the more exacting requirements for teaching. Many young instructors remark that they really didn't begin to master a subject until they had to teach it. At first, in most established departments, the young instructor will need to make very few decisions in regard to course outlines and text books. Above all he will meet his classes with little more knowledge of how to teach than he can remember about the methods employed by some of his former professors. The merit and effectiveness of these vaguely recalled methods are seldom challenged. It is little wonder that the young instructor will devote much of his time and effort to check if the students can remember the text they studied the day preceding. He will spend considerable time in explaining the derivations of formulas which are well presented in the text book but which may have had a few simple algebraic steps omitted. He will also devote some time to the explanation of the next day's assignment. It is no exaggeration and a sad commentary on the teaching methods employed in engineering to state that the methods here attributed to the young

instructor are in too many instances the methods employed by senior professors in senior subjects.

To correct this situation at the earliest possible opportunity the young instructor should obtain some good books on "How to Study." The chances are that no one took the trouble to call to his attention that there are principles and methods on how to study effectively. While he was a student he just trusted to luck that his improvised procedure would yield results. He invested four years of his time and money in a college education without questioning whether he was studying and learning or merely memorizing facts and imitating methods. As a young teacher he will have to know how to study because he will have to study by himself if he is to get anywhere as an engineer and an educator.

As soon as possible after the first year the young instructor should arrange a definite program for studying the art and science of teaching. There are several ways to acquire these skills. Where no formal opportunities exist he should search the library stacks until he finds a few good books on educational psychology and on teaching methods. Perhaps, a planned conference with a member of the Department of Education will enable him to select his books more objectively. Having selected one or two likely texts he should study these as systematically and thoroughly as he studied his engineering texts. As he masters the subject chapter by chapter he should start at once to apply the principles and techniques to the daily teaching of his classes. This formal study of one or two texts should be accompanied by reading the references suggested in the text. Other good supplementary material can be found by regularly referring to the *Journal of Engineering Education.* It is assumed of course as mentioned earlier in this paper that the young instructor joined the American Society for Engineering Education at his earliest opportunity. This affiliation will awaken a genuine interest to use improved teaching methods, it will develop enthusiasm for the teaching profession, and it will provide, in addition, a fine background for a broad understanding of the objectives and philosophy of engineering education.

Another way to improve one's skill in teaching is to organize a small discussion group at the beginning of the academic year. The size of this group should be limited to eight or ten young engineering instructors. Two one-hour meetings a week would provide a 60-hour course before the end of the school year. The selection of the leader should be based on his proven ability to lead his classroom discussions on teaching methods and on his desire to help young engineering instructors establish permanent interest in good teaching.

It was the writer's privilege to organize a group of this kind more than twenty years ago. Twice each week Professor W. H. Lancelot, then Head of the Department of Vocational Education at Iowa State College, held a seminar class between four and five in the afternoon. The topic, Teaching Skills, was thoroughly discussed by the group under his skillful guidance. The subject was tactfully and painstakingly developed by class discussions of the following skills:

1. *"Developing Permanent Interest."* Developing in the students an enduring interest in the subject or course that they are to study.

2. *"Creating a Feeling of Need."* Arousing and sustaining in the class a feeling of need for the knowledge to be learned or for the skill to be acquired, before either teaching it or requiring that it be studied.

3. *"Making Internal Connections"* The interest of the class can be carried from one part of a course or subject to another by relating the new work to that with which the class is already acquainted.

4. *"Making External Connections."* There are many natural and close connections with facts and experiences outside of a topic or course which the alert

teacher can make and in which the students themselves are already interested.

5. *"Involving the Natural Impulses."* A number of natural impulses such as activity, curiosity, creativeness, self-advancement and others should be involved in the planning of a study assignment or class exercise.

6. *"Replace Routine Memorization with Interesting Thinking."* Each essential fact, principle or law can be introduced by a specific problem.

7. *"Creating and Maintaining Suspense."* In every class a state of suspense regarding the outcome will generate spontaneous thinking among the students.

8. *"Developing the Ability to Think Well."* Before the students are willing to substitute good thinking for memorized methods and procedures they must become deeply interested and keenly aware of the need for and value of the ability to think well.

9. *"Finding, Judging and Using Problems."* As a rule problems that represent typical and recognizable life situations are considerably more effective than artificial problems.

10. *"Presenting the Problem."* In general each new problem should be the outgrowth of previous problems which the students have solved by good methods of thinking.

11. *"Planning for the Class Discussion."* Good class discussion is the essence of good teaching. When a teacher can reverse the usual custom of speaking 90 per cent of the hour, he may consider himself to be on the road to success. A good discussion moves along to accepted conclusions.

12. *"Leading the Class Discussion."* The problem should be stated in an interesting and clear manner. A number of viewpoints should be encouraged so that certain members of the class will take sides to support each idea proposed. The teacher can hold the balance of power first throwing his support to one side and then the other. By this procedure the students will be stimulated to think up ideas to prove their points.

13. *"Questioning."* At the beginning of each class call upon those who appear to be keenly interested. Then tactfully bring into the discussion the remaining members of the class.

14. *"Selecting the Fact Materials to be Taught."* To select wisely the teacher should list the facts, interests, ideals, abilities, processes and principles which are to be developed during the progress of the course. These major items of subject matter will necessitate the introduction of certain additional supporting informational, factual and theoretical subject matter. By reviewing frequently the contents on basis of absolute necessity, only the essential material will remain.

15. *"Measuring the Results of Teaching."* This skill has a twofold application. First the teacher should plan his questions carefully so that his tests will reveal the power of thinking as well as the quality of knowledge acquired by his students. Second, the teacher may occasionally seek the appraisal of his teaching effectiveness by his students. He may from time to time request them to fill in statements on "Teacher Rating Sheets." These sheets should become the property of the instructor so that he may study and interpret them with a view to self-improvement.

These skills have been enumerated so that the young instructor who wants to improve his teaching ability can plan a reading and study program. He may even organize a small seminar group in which each member would undertake to prepare discussions for developing one or more of these skills and then to lead group discussions on the topics he studied.

It has been frequently stated that an important, if not the most important, function of the teacher is to provide conditions which will enable each student to develop to the fullest extent his natural ability to think. Human beings have been endowed with a brain that possesses the power of solving problems,

that is to think. As recently as in the April 1950 issue of the Journal of Engineering Education, page 417, Dean Hammond again called to our attention that "good teaching is the development of the student's ability to do things for himself." It has been the writer's conviction that the objective—the student's ability to do things for himself—could be definitely achieved only by teaching in such a way that the emphasis is *always on the development of the thinking power of each individual* to the extent of the inherent capacity of the student's brain. If personal references may be pardoned the reader is urged to consult two texts which were so written that the initiative for solving problems, namely, the association of a new situation with past experiences is left largely to the student. These texts are: (1) The Theory of Engineering Drawing with Applications; and (2) Analysis and Design of Steel Structures. The act of thinking should not be left to chance of the development of the student's ability to do things for himself.

Fortunately there are teaching principles and procedures which will enable each person to strengthen his inborn capacity to think. To use and apply these principles and methods the teacher himself must devote serious attention to the full understanding of the science of teaching and to the trained skill of applying this science to the development of the student's ability to think.

Other excellent programs available for the technical development of the young instructors are well known and long established. One plan is to take advanced work under the stimulating guidance of capable engineering teachers. These graduate studies lead to the established Master's Degree and the Doctor of Philosophy Degree. Another program involves the pursuit of research in the teacher's field of special interest and ability.

A word of caution is needed at this point. Graduates study and research are of proven value to develop the mature thinking and the advanced knowledge of a person, but only when his teachers stress the strengthening of the person's capacity to think. Furthermore it is expecting too much of graduate study and research programs to imply that these disciplines automatically develop in a person and understanding of the science of teaching and the skill to apply this science in developing the thinking power of the individual. Fortunately, the Creator made man so that he naturally grows in his power to think. If this were not so, the body of knowledge and achievement of the human race would not be where it is today. However, the effective and good teacher provides the intellectual stimulus and scientific background whereby his students definitely and progressively develop their thinking technique.

There is a science and method for designing bridges, generators, jet turbines and airplanes. Men no longer build these engineering creations by guess; they build them by basic science and proven processes. Therefore, the young instructor who aspires to become an effective teacher will master the science of education and the methods of applying this science to the development of the individual's ability to think and, then, to do things for himself.

Becoming a Leader of Men

The engineering teacher is in a unique position to become a leader of men, an inspiration to his students. In fact, he must become a leader of men so that his students may acquire, through direct contact, those qualities which will make their services desired by their professional associates and by the citizens in their communities.

Engineering is one of the newest professions. Engineering education in this country has hardly reached its one hundred and fiftieth anniversay. Yet, today, it is among the foremost in vitality, progressiveness and importance. For example, the daily activities of the farmer are frequently dependent upon the work of the engineer. The farmer receives

energy from extensive rural electrification systems, he operates his farm with many varieties of power driven equipment, and he maintains his contact with adjoining cities by transportation facilities offered by automobiles, trucks and good roads. In a similar manner, comfortable and healthy living conditions in our cities, especially the larger ones, are made possible by the works of the engineer who is responsible for the abundant supply of good water, for the removal and purification of used water, and for the construction of rapid transit systems and structures to meet many needs. Both on the farm and in the cities people can communicate conveniently and effectively by telegram, telephone, radio and television. Since the works of the engineer influence modern life at so many points of contact he should actively concern himself with the problems of his community. It is little wonder, then, that engineering education is proving to be the "general education" for fitting into one's environment and for work in many professions. Society is recognizing that a person with an engineering education acquires discipline in careful, accurate and thorough work and in the systematic and scientific method of basing conclusions on practicality, controlling conditions and verifiable facts.

The engineering teacher who prepares and adheres to a program of becoming a good engineer and an effective teacher possesses excellent opportunity for becoming a leader. For the young man who consciously thinks in terms of service to his students, to his profession and to his community, the educational environment offers an effective medium for the development of leadership. Teaching and the development of leadership, are, or should be, synonymous. By the very nature of his work the engineering teacher tends to deal with the improvement and advancement of the art and science of engineering.

In his daily relations with different groups of students he tends to stress the importance of engineering technology and science in the thinking and activity of his community. He is not completely absorbed in the solution of engineering problems but he is intensely involved in dealing with human beings. He is not satisfied in transmitting only the "know-how" of the profession. He emphasizes "know why. when and where." He is on the alert to learn about or contribute to new improvements in methods, procedure, application and theory. He does not have at his disposal the weekly or monthly paycheck for motivation of his students. He must rely entirely upon his teaching skill to spur young men to high achievement in technical proficiency, personal effectiveness and community responsibility. As a leader, the teacher should think and act in such a manner that his knowledge is respected, his counsel is sought, his judgment is accepted, his requests are fulfilled, his proposals are put into action and his integrity is unquestioned.

In the early years of his teaching experience the young instructor has more freedom to exercise judgment in initiative than that afforded to young men starting to practice engineering. Society affiliations, committee memberships and research activities provide for professional growth. Class room contacts and other faculty responsibilities provide for growth in handling men and for establishing good public relationships. Other outlets for the skill of the young instructor are participation on committees, commissions and boards of the local government and voluntary citizen groups. At first this participation will be modest but on the basis of satisfactory performance the degree of responsibility assigned will grow in proportion to the service rendered by the young instructor.

The self-planned program for the young instructor will provide for his professional growth, for his advancement in the applications of the skills and science of teaching, and for his participation in community affairs. The success of this pro-

gram depends entirely upon the determination, consistency, and judgment with which the young instructor applies himself. The head of his department and the administrative officers of his institution will be pleased to observe and will gladly support his initiative in preparing himself to become a good engineer, an effective teacher, and an active participant in the worth-while programs of his community, be it the home town, the state or the nation.

Cooperative Education Division

Mid-Winter Meeting

By C. E. WATSON

Chairman, Department of Industrial Relations, Northwestern University

The Cooperative Education Division of the ASEE held its mid-winter meeting on the beautiful campus of the University of Florida in Gainesville, Florida, January 9–10, 1951. The sessions were particularly informative, last minute insertions being made in the agenda to cover current problems and the place of cooperative colleges in the national emergency.

A significant paper, entitled "What Type of Training Should Industry Provide for Cooperative Engineering Students?" was given by Mr. Thomas Hand, Acting Head of the Research Department, Corhart Refractories Company, a cooperative student himself in the not-too-distant past. Other men from industry who spoke in support of their individual co-op training programs and outlined their various techniques and points of view included Mr. J. S. Gracy, Vice President of the Florida Power Corporation, Mr. W. E. Gift, Assistant Supervisor of Personnel, Tennessee Eastman Corporation, and Mr. Gordon L. Robertson, Supervisor of Training, Alabama Power Company, who stressed "The Co-op Viewpoint."

Mr. Joseph Hilsenrath, who has been a staunch supporter of cooperative training in the National Bureau of Standards, gave an interesting review of "Cooperative Students and the Civil Service System."

Some of the problems of starting a Cooperative Education program from scratch were covered by Dr. Homer D. Fetty of Los Angeles State College who has been doing just that. An extensive survey conducted by Dr. Fetty indicates that West Coast employers are overwhelmingly enthusiastic about Co-op and are willing to lend their support.

"Interviewing Techniques as Applied to Specific Co-op Procedures" was the topic of a talk by Mr. W. E. Nightingale of Northeastern University containing many timely tips for Coordinators.

Mr. C. J. Riedy, University of Detroit, mentioned a statement once made by Dean Sherwood of M. I. T. that "We had better adjourn before someone brings up the subject of report writing" and then proceeded to cover the topic, "Work Reports—A Student Training Aid" in fine fashion.

Before heading back to the land of snow and ice, the Cooperative Division voted to accept the invitation extended by Prof. C. E. Watson on behalf of Northwestern University to hold the next mid-winter meeting on the Northwestern Campus in Evanston, Illinois. This will be one of a number of significant meetings to be held at Northwestern in celebration of this illustrious University's Centennial year.

Safety Integration Procedures*

By S. S. STEINBERG

Dean, College of Engineering, University of Maryland and Chairman, Committee on Education, President Truman's Conference on Industrial Safety

As a result of recommendations made by the Committee on Education of the President's Conference on Industrial Safety at its meeting in Washington last June, the University of Maryland offered the use of its College of Engineering for an experimental endeavor to determine a practical method of integrating safety into the engineering curricula. The Bureau of Labor Standards, U. S. Department of Labor, was requested to cooperate in this project.

The initial conferences revealed that it would not be feasible to integrate safety into all the existing engineering courses at this time. Therefore, for this first experimental year, integration activities were limited to the Mechanical Engineering curriculum, out of which 16 courses were selected as best suited to integrate accident prevention. The experience gained in the selected courses of the Mechanical Engineering curriculum will be utilized to develop integration material later for the other engineering departments.

Freshman Year

It was felt that sometime during the freshman year the prospective engineer should become acquainted with the accident problem and its magnitude in this country. It was suggested that a practicing safety engineer address the freshmen concerning these problems in the freshman course in Introduction to Engineering, and at the same time point out the safety responsibilities and duties of professional engineers. Also, during the freshman year, safety will be integrated into the English courses, namely, Composition and Literature. This integration will take the form of themes relating to safety and will be coordinated with the current work of the freshman classes in English. Safety will also be integrated into the Public Speaking course for freshmen. This integration will follow the pattern of the work done in the Composition and Literature courses. We are fortunate at the University of Maryland in having departments in English and in Speech which are readily willing to cooperate in our proposals.

Sophomore Year

The integration procedure used for the sophomore year is an attempt to bring safety to the functional level. This was done by inserting material in the texts used for shop work. These insertions are given to the shop instructors to fit into their outlines as they deem best. In addition, sufficient material was developed to aid the instructor in integrating safety into the actual practice work done in the shops.

Manufacturing processes, which is a vital part of the Mechanical Engineering sophomore year, was chosen as an ideal course for safety integration, as the student engineer at this time first becomes familiar with the various methods of manufacturing. In this instance, a supplement was written to the text used, and the instructor will incorporate this ma-

* Presented at the National Conference on Safety Education by Colleges and Universities, Cincinnati, Ohio, November 19–21, 1950.

terial in his present outline. In addition, many references were given to nationally accepted standards with the expectation that the student engineer would also familiarize himself with this material.

Junior Year

The courses in the junior year of the Mechanical Engineering curriculum are basically theoretical in nature and little of the laboratory work permits of safety integration. The only possibility in this year is occasionally to provide a lecture with supplementary reading material so as to keep the student conscious of the safety problem as it will affect him in his future relations with industry.

Senior Year

The integration procedure for the senior year was through the medium of specific insertions in the rather specialized courses. Refrigeration and Air Conditioning, Design of Machine Elements, and Mechanical Engineering Practice, are examples of the more specialized courses for which specific insertions were made. It was felt that integration should be by textbook insertion, and also by supplementary material. Here again the student engineer is expected to familiarize himself with those standards which are applicable to the particular course of study.

This brief resume gives a general idea of the safety integration procedures used by the University of Maryland. It is our present thinking that integration into engineering is the proper approach since it builds the safety factor into specific courses, and causes the student engineer to think of production, efficiency, and safety simultaneously. This attitude somewhat parallels the phrase that "safety and production should go hand in hand" rather than be separated. What we hope for eventually is that in the future revisions of engineering textbooks, we may have safety procedures incorporated into the instruction material.

It would be difficult to evaluate mathematically the importance of our efforts in promoting safety education in the training of our future professional engineers. We must realize that the men we are training in our engineering colleges today will be the industrial leaders of the future, and their consciousness of safety should have a tremendous beneficial influence on the reduction of industrial accidents.

Promotional System Variables for Engineering Faculties*

By HARRY W. CASE

Associate Professor of Engineering and Psychology, University of California, Los Angeles

Recognizing the pitfalls and sources of error in the "scientific method" of employee evaluation, many college administrators have shown extreme caution in applying evaluatory techniques in appraising their faculties. Expanding student enrollments, with equivalent growth of academic, non-academic, and research employees in engineering colleges, have however increased the need for adequate information on existent promotional policies in engineering schools. Information compiled in this survey on current promotional practices may prove of benefit to administrators.

Questionnaires were sent to universities, state colleges, colleges, and technical institutes, in care of their respective deans as indicated by the Directory of the American Society for Engineering Education. Replies were received from fifty-three universities, twenty-six colleges and state colleges, and ten technical institutes, all of whom had a curriculum in engineering.

The questions and the percentages of replies received are shown in Table 1. In each instance the percentages indicate the proportion of the total of that type institution which replied to the question. The percentages indicated for each question do not equal 100 per cent because of omissions of various questions by different schools. Questions 6, 10, 13, and 14 are not included in this table because the nature of the questions does not lend itself to percentage compilation. Tables 2, 3, and 4 present graphically questions 6, 13, and 14, respectively.

Question 10 which read: "If a written evaluation system is used, please list the qualities evaluated, such as:

a. Teaching ability
b. Attitude, etc.

OR, PREFERABLY, ATTACH A SAMPLE COPY OF THE RATING SHEET."—

was not compiled into tabular form since no technical institutes and only five of the colleges replied listing factors or enclosing a sample rating form. Four universities sent copies of their formal rating sheet, while seven listed qualities used in the written evaluation system. In schools sending copies of their evaluation system, there was little similarity in the mechanics of the systems used. They ranged in type from a linear continuum, with provision made to place a point on a line indicating the degree of the quality possessed, to a simple alphabetical system in which a descriptive phrase of the quality was associated with a letter ranking. One of the scales used a simple numerical system, and still another used a straight subjective essay covering each of the points on which the individual was being evaluated. In terms of complexity they varied from a simple rating scale with very little explanatory material to a complex and detailed scale, accompanied

* Presented at a meeting of the Educational Methods Division at the ASEE Annual Meeting, Seattle, Washington, June 22, 1950.

TABLE 1

ANSWERS TO QUESTIONS 1 THROUGH 5, 7 THROUGH 9, 11, 12, AND 15

The percentages indicate the proportion of the answers received from the specific type institution. Various institutions omitted various questions.

Questions	Universities		Colleges and State Colleges		Technical Institutes	
	Yes	No	Yes	No	Yes	No
1. Does your university have a standard promotional procedure?	34%	53%	35%	54%	50%	50%
a. For academic personnel?	36%	30%	38%	19%	30%	10%
b. For non-academic personnel? (Excluding research)	15%	45%	31%	23%	10%	30%
c. For personnel engaged solely in research?	15%	42%	12%	34%	10%	20%
2. If your university does have a standard promotional procedure, is it in effect in the College of Engineering?	34%	—	42%	8%	30%	—
a. For academic personnel?	34%	—	42%	4%	30%	—
b. For non-academic personnel?	15%	13%	31%	11%	10%	20%
c. For personnel engaged solely in research?	13%	9%	12%	23%	10%	10%
3. If your university does not have a standard promotional procedure, does the College of Engineering have one?	4%	45%	12%	45%	10%	50%
a. For academic personnel?	—	24%	12%	11%	—	10%
b. For non-academic personnel?	—	24%	—	15%	—	10%
c. For personnel engaged solely in research?	—	24%	4%	19%	—	10%
4. Is this promotional procedure administered by:						
a. An administrative officer in the university?	26%	8%	23%	4%	20%	—
b. An administrative officer of the College of Engineering?	21%	9%	27%	—	10%	—
c. By a committee?	11%	15%	4%	11%	10%	—
d By a committee making recommendations which are acted upon by an administrative officer?	19%	11%	15%	12%	10%	10%
5. If you use a committee, is it composed of:						
a. Joint membership of Engineering and other academic departments?	11%	13%	12%	3%	10%	—
b. Solely membership of College of Engineering?	6%	13%	12%	3%	—	—
c. Solely Engineering Department membership?	8%	16%	4%	4%	—	—
d. Solely other academic membership?	2%	17%	4%	4%	—	—

TABLE 1—*Continued*

Questions	Universities		Colleges and State Colleges		Technical Institutes	
	Yes	No	Yes	No	Yes	No
7. In ascertaining the eligibility of an individual for promotion, what type of written evidence is accepted?						
a. Publications?	58%	6%	35%	11%	30%	—
b. Written recommendations?	43%	14%	50%	12%	30%	—
c. Some form of rating evaluation?	23%	20%	23%	15%	20%	20%
8. If an evaluation system is used, is it?						
a. A method of rating individuals from best to poorest by overall ability? I.e., 1. Scott—best; 2. Jones—next best; 3. Smith—next best.	9%	25%	4%	15%	10%	10%
b. A rating system in which the individual is placed on a continuum or scale? I.e., rated on certain qualities and the totals obtained?	11%	21%	12%	11%	10%	—
c. A short written description of his activities is prepared or written statements made to certain questions?	23%	13%	27%	8%	10%	—
9. If an evaluation system is used, does it result in:						
a. A score for the individual?	8%	24%	8%	15%	10%	—
b. A letter grade?	—	26%	—	19%	—	—
c. A series of marked descriptions?	8%	20%	—	19%	10%	—
d. A written statement?	23%	13%	27%	8%	—	—
11. Are the faculty required to utilize an analysis of their teaching:						
a. Filled out by themselves?	2%	51%	—	57%	—	10%
b. Filled out by the students?	13%	45%	15%	54%	20%	—
c. Filled out by an administrator?	13%	44%	—	54%	10%	10%
12. Are the results of the evaluation made known to the faculty member?	13%	30%	23%	15%	20%	10%
15. Do promotions within the Engineering Department occur:						
a. More frequently than in other academic departments?	6%	30%	12%	23%	10%	20%
b. Less frequently than in other academic departments?	2%	26%	—	19%	—	20%
c. Approximately the same as in other academic departments?	70%	2%	62%	—	40%	—

TABLE 2

6. In recommending promotions, the factors taken into consideration are: (Indicate percentage of total.)

	Universities												Colleges and State Colleges								Tech. Inst.
	A	B*	B†	C	D	E	F	G	H	I	J	K	A	B	C	D	E	F	G	H	A
a. Teaching ability	25			35	30–45	70	70		25	50	15	52	50					50	20		60
b. Teaching load	5			5					15	25			10								
Sub-Total	30	50	30	40	30–45	70	70	65	40	75	15	52	60	50	25	60	50	50	20	70	60
c. Research ability	5			15	5– 5	5	5		10	5	5	8	15						10		5
d. Research load	5			3		5						8									
e. Research publications				7	15–15		5			5	10	8									
Sub-Total	10	15	15	25	20–20	10	10		10	10	15	24	15			5	20		10	5	5
f. Development ability				1					5		5	2						25	10		10
g. Development load				1					5			2									
h. Development publications				3																	
Sub-Total	5	10	15	5				5	10		5					5		25	10		10
i. Administrative ability	5			3	15– 0	5			5		5	2							10		
j. Administrative load	10			1					5		5	2							5		
k. Administrative publications				1																	
Sub-Total	15		7½	5	15– 0	5		20	10		10	4		20	5	5			15		
l. Committee ability	15			3	5– 5					5	5	2									5
m. Committee load	5			1						5		2									
n. Committee publications				1																	
Sub-Total	20	10	7½	5	5– 5				5	10	5	4			10	10				5	5
o. Student counseling and guidance ability	10			2		5	10		4		5	2						15	10		10
p. Student counseling and guidance load				1					3			2									
q. Students' reports on counseling and guidance				2					3		5										
Sub-Total	10			5		5	10	5	10		10	4		20	10	5		15	10	15	10
r. Public service ability				1	5– 5				5		5	2						10	10		
s. Public service load				4					5			2									
Sub-Total				5	5– 5				10		5	4		10	10		10	10	10		
t. Writings—texts				5						5	5	2				5					5
u. Writings—research publications				4							10	2									5
v. Writings—other				1																	
Sub-Total			10	10	10–10			5	5	5	15	4			15	5	20		10	5	10
w. Other	10	15	15		15–15	10	10				20		25		25				15		
Total												11								8	1
Percentage of returned questionnaires												21								31	10

* Junior appointments.
† Senior appointments.
Note: Arrows refer to distribution of sub-total.

by comprehensive instructions, designed to cover many job qualifications of the individual being evaluated. From the limited sample it would appear that the scales developed for evaluation purposes in the universities and colleges have a surface validity comparing favorably with those used in private industry.

Schools which listed the qualities shown on their evaluation forms, but failed to enclose an evaluation sheet, included the following factors:

Teaching ability
Personality
Use to the institution
Academic training
Experience
Supervision exercised
Public service
Interest in students in school

TABLE 3

13. At what time intervals are the faculty members evaluated?

PERCENTAGE OF RETURNED QUESTIONAIRES

Time Intervals	Universities	Colleges and State Colleges	Technical Institutes
Twice a year		4	
Yearly	36	54	60
Two years	2		
Three years		4	
Irregular	11	4	
Continuously	4		

Responsibility for methods and policy
Responsibility for records, reports, and schedules
Responsibility for machinery, equipment, and safety
Responsibility for public relations
Responsibility for non-academic duties and committee work
Professional activity outside of classroom
Ability and activity in research
Acceptance by students and colleagues
Attitude
Writings
Student counseling ability
Administrative ability
Professional standards
Laboratory ability.

The factors utilized in the evaluation systems of different institutions differ greatly. However, six institutions listed teaching ability, five attitude, four personality, and two research ability. The remaining factors occurred only once in each of the listings.

Table 2 (in which the specific weights assigned promotional factors are indicated for twelve universities, eight colleges, and one technical institute) emphasizes the difference of opinion existing as to the importance assigned to various tasks in the determination of promotions. It is interesting that the institutions answering this question assigned weights ranging from 15 to 75% to the general area related to teaching in determining promotions in the universities, while the range was from 20 to 70% for the colleges and state colleges. Unlike the popular conception that research is the sole criterion, the weight assigned ranged from 10 to 25% for the universities and from 5 to 20% for the colleges. Seventeen institutions reported they had no specific percentages but considered all the factors listed, while others stated that they had not determined percentages but considered specific items. Of eleven schools which answered the question but said they used no specific percentage, *teaching ability* was listed eleven times; *research ability* nine; *research load* eight; *student counseling and guidance ability* seven; *administrative ability* six; *committee ability* five; *research publications, writings—texts,* and *writings—research publications* four each; *teaching load,* and *writings—other* three each; *development ability,*

TABLE 4

14. What is the usual length of time elapsing between promotion from one academic rank to the next?

PERCENTAGE OF RETURNED QUESTIONNAIRES

Yearly Intervals	Universities	Colleges and State Colleges	Technical Institutes
1– 5	2		
2– 3		4	
2– 5	2		
2–10	2		
3	6	4	
3– 4	2		
3– 5	4	4	10
3– 6	2	8	
3– 7	2		
3– 8	2		
3–10	4		
4	2	4	
4– 5		15	
4– 6			10
4–10	2		
5	2	4	
5– 6			10
5– 7			10
5– 8	2		
5–10		4	10
Irregular	30	23	10

committee load, and *public service ability* two each; and *reports from students* and *other* one each. Nine wrote in their covering letter that they did not believe in any system which considered specific factors or assigned weights to specific areas, but preferred to judge the individual on the basis of his "merit", but unfortunately they did not indicate how this was determined.

Table 3 tabulates the percentages of replies received to the question: "At what time intervals are faculty members evaluated?" While yearly evaluation of the faculty member is the most common, a surprisingly large number of universities (11) and colleges (4) indicated that they had no fixed time interval for evaluation. This may be reflected in one of the replies which read in part: "Practically all the promotions that I have seen since my stay here have been more or less accidental and not due to any plan."

Question 14, "What is the usual length of time elapsing between promotion from one academic rank to another?", is tabulated in Table 4. The poor wording of the question, which did not allow for a sliding time period for promotion from different ranks, is no doubt partly responsible for the fairly wide ranges indicated by some of the schools furnishing data. The explanations that accompanied many of the returned questionnaires indicated that in some instances a three-year period was observed for promotions from one rank to the next for all academic grades, while in other instances the time elapsing was greater if the individual being promoted was of a higher rank. In one case the reverse was true and the longest elapsed time was from instructor to assistant professor. Almost half of the institutions appear to have no formal or customary length of elapsed time between promotions.

An examination of the questions tabulated in Table 1 reveals certain trends. With the exception of the technical institutes, less than half of the institutions replying have a standard promotional procedure, and the chances of an institution's having one for research personnel is less than for academic personnel.

Question 2 seems to show that if the university has a standard promotional procedure, it is also used in the college of engineering for engineering academic personnel. Other personnel do not appear to fare quite so well. In relatively few instances is the college of engineering pioneering in the field of promotional procedures, for the percentages shown in the answers to question 3 indicate that if the university does not have a standard promotional procedure, the engineering college has not attempted to institute one.

The answers to question 4 show that the promotional procedure is administered by an administrative officer of the university or of the college of engineering, and to a much lesser degree by the action of a committee, although in a fairly large number of cases a committee makes recommendations which are acted on by an administrative officer.

When a committee system for promotion is used, it would appear common practice to have the committee formed of members selected from engineering and other academic departments. Surprisingly enough 2% indicated that the committee was entirely composed of members of departments other than engineering.

Question 7 reveals that while publications are the most common type of accepted promotional evidence, written recommendations are also heavily favored, and approximately one-fifth to one-fourth of the schools accept some form of rating evaluation. Question 8 indicates that although the short written statement is used in many institutions, the rating continuum is acceptable, and in some instances the method of absolute ranking is followed. In terms of the evaluation system it appears that the most common form is the type which results in a written statement. A series of marked descriptions and a score for the individual remains in second order of frequency.

Roughly 26% of the universities re-

plying to the questionnaire require the faculty to utilize an analysis of their teaching, either filled out by an administrator or by the students.

Finally, question 15 shows that in the majority of instances promotions occur within the engineering department in approximately the same time sequence as in other departments.

Many helpful replies were received in the form of letters that accompanied the returned questionnaire. It is unfortunate that they must be treated as confidential. In general it may be said that the reception to the questionnaire ranged all the way from indignation on the part of some of the smaller institutions, who appeared to be irritated at what they felt was a suggestion that they needed a system for promotions, to outright request for copies of the data as soon as it could be compiled. Many institutions were in the process of investigating the promotional policy with a view toward attempting to correct many of the evils which appeared to have existed in the past. One thing that stood out clearly was that there is relatively little current knowledge concerning the factors or the systems in use in other institutions.

ANNUAL MEETING

MICHIGAN STATE COLLEGE

June 25-29, 1951

EAST LANSING, MICHIGAN

Experience Credit Toward the Professional Engineer's License for Technical Institute Study*

By HAROLD P. RODES

Assistant Director of Relations with Schools and Assistant Professor of Engineering, University of California, Los Angeles

Stimulated in 1929 by the Wickenden report on engineering education, which included a major section on technical institute training, the tie between professional engineering and the technical institute type of engineering education has been becoming gradually closer and more friendly. Some of the tangible evidences of this relationship are the establishment of the Technical Institute Division of the American Society for Engineering Education and the Subcommittee on Technical Institutes of the Engineers' Council for Professional Development. Just as the medical profession, for example, recognizes that its effectiveness is due partially to the quality of its nurses and medical assistants, so does the engineering profession now recognize in the main that its effectiveness is due partially to the quality of its technicians and engineering aides.

We know, of course, that this improved relationship is not free from areas of irritation to the engineer and the technician, both in industry and in education. Some of the basic problems which remain to be solved include the lack of agreement on terminology, the difficulties encountered in the transfer of technical institute graduates into a professional engineering curriculum, and the establishment of a general policy concerning the granting of experience credit for technical institute training toward the professional engineer's license. For the purposes of this discussion we shall limit ourselves to the last of these problem areas.

Results of Survey of State Policies

Several months ago Dean L. M. K. Boelter requested the Executive Secretary of the National Council of State Boards of Engineering Examiners to undertake a survey of the practices employed in the various states with respect to the granting of experience credit for training of technical institute type. Accordingly, each member state was asked to indicate whether or not it gives experience credit for training received in ECPD accredited technical institute curricula.

The replies were extremely interesting for several reasons. They indicated not only a wide variation in practice from one state to another, but in several cases a complete lack of understanding of the question.

A tabulation of the replies received to date shows that six of the thirty-two states replying grant full experience credit toward a professional engineer's license for ECPD accredited technical institute training; seven states grant no credit; six states grant partial credit; the boards of five states have not yet decided upon a policy for granting credit; five states answered the question as relating to ECPD accredited "engineering" curricula; and three states frankly admitted that they did not understand the question.

* Presented before the Annual Meeting of the Pacific Southwest Section of the American Society for Engineering Education at the University of Southern California, December 28, 1950.

If the states replying with an unequivocal answer can be taken as an adequate sampling, it would appear that the boards in approximately one-fourth of the states are granting full experience credit for ECPD accredited technical institute training toward the professional engineer's license; that about one-fourth are granting no credit whatsoever; that another fourth are granting partial credit; and that in the final fourth the state boards have not yet considered the problem. However, in addition to this last fourth it is apparent that many other states have made their decisions in this matter tentative and subject to change on the basis of additional evidence and argument.

Although it is not the purpose of this paper to launch a crusade for complete standardization in the acceptance of experience credit for technical institute training, I do believe that it is somewhat embarrassing and difficult for the engineering profession to explain why the licensing boards in some states grant full credit while the boards in other states grant no credit for ECPD accredited technical institute training.

Before describing the policy which, in my opinion, represents the most rational and realistic approach to this problem, it might be well to review briefly some of the arguments which have been advanced by the two extremes mentioned previously. The state boards which grant full credit have proceeded on the assumption that two years of technical institute training is the equivalent of two years of enginneering training insofar as professional preparation is concerned, an assumption that is questionable in the minds of many. The opposite point of view can perhaps be best presented by quoting the reply received from a member of one of the state boards:

"This matter has not as yet come before the Kentucky Board, but I think I can safely say that we will not give experience credit for work in technical institutes. Having sat in on a number of meetings of ECPD when this situation was discussed I can further say that ECPD certainly does not consider attendance at technical institutes, even though accredited, as having anything to do with registration as a Professional Engineer. I think the reason that ECPD has undertaken this work at all was because they have felt that something of the sort should be done in order to insure a supply of competent technicians but they do not expect the technical institutes to be considered as training Professional Engineers. The two things are entirely separate and distinct."

Like many other issues, this one also has two sides. Each of us probably has an opinion on this particular issue which may be quite close to one side or the other. I suspect, however, that the majority of us, as well as of the state licensing boards, will eventually agree that the ultimate solution lies somewhere between the two extremes.

California Plan

Of the several plans for granting partial credit, I believe that the "California Plan" has the greatest promise. In Section 409 of the California Administrative Code, the State Board of Registration for Civil and Professional Engineers was granted the authority to (1) "give partial credit for the completion of an approved curriculum of technical institute type," and (2) "accept the technical institute type curricula which have been approved by the Engineers' Council for Professional Development."

In order to implement the above legal authorization, the California Board adopted the following resolution: "Moved by Mr. Sullivan, seconded by Mr. Sorensen, that graduates from a technical institute curriculum accredited by the Engineers' Council for Professional Development be given one year's credit toward experience. . . . Motion carried." *

Stated differently, this resolution means that accredited technical institute train-

* Minutes of the California Board of Registration for Civil and Professional Engineers, May 17, 1949.

ing, which is normally of about two years in duration, is considered to be the equivalent of about one year of professional engineering training. An examination of ECPD accredited technical institute curricula indicates that such an evaluation is not far from the actual fact. For example, one accredited technical institute curriculum in the State of California includes courses in Applied Mathematics through Calculus, Aircraft Drafting and Detail Design, Applied Mechanics, Engineering Shop, Technical Report Writing, Elementary Physics, Aerodynamics, and Stress Analysis. Although the objective, and therefore the content of these courses differs considerably from that of the four and five year ECPD accredited engineering curricula, experience has shown that the graduate of such a curriculum who indicates aptitude for professional engineering training can probably complete a four year professional curriculum in about three years. Thus, the decision by the California State Board to grant one year of experience credit for the completion of approximately two years of ECPD accredited technical institute training appears to be a realistic and practical one.

There are undoubtedly those, even in this state, who feel that the Board should not grant any credit, or that it should grant full credit for ECPD accredited technical institute training. There are others who feel that the Board should not restrict the granting of partial credit to those curricula which have been accredited by ECPD. I believe we would all agree, however, that unless certain standards are maintained the licensing of professional engineers is meaningless. Possibly ECPD accreditation is not the only or even the best method of maintaining sufficiently high standards for purposes of registration. Nevertheless, until some of the closely related problems such as terminology and transfer are solved, ECPD accreditation appears to be the only sound educational basis for the granting of experience credit toward the professional engineer's license.

At the present time there are only two institutions in the State of California which are offering technical institute curricula that would qualify for partial experience credit. Even if this number should be greatly increased by the accreditation of technical institute curricula in other private and public institutions, the total number of technical institute graduates applying for professional registration will never be very large. Nevertheless, if the engineering profession is to maintain its current development in a true professional sense, and at the same time avoid some of the errors and inconsistencies which have been plaguing certain other professions, it appears desirable and even essential that the "California Plan" for the granting of experience credit for technical institute training should be continued in this state and considered in some appropriate form in other states.

A Modified Sequence in Teaching Mechanics of Materials*

By E. P. POPOV

Associate Professor of Civil Engineering, University of California, Berkeley

Introduction

Four years ago, after ten years of engineering practice, I returned to academic life and became immediately associated with the teaching of Mechanics of Materials. As is known to all of us, at that time the major segment of the student population was composed of war veterans. Also, as we all know, this group of students was unusually eager to learn conscientiously the subjects of the prescribed curriculum. Yet this determined hard-working group of students appeared to have some basic difficulties in mastering certain portions of our introductory course in Mechanics of Materials. What was the trouble?

Frankly, at first I attributed these difficulties to my being out of touch with academic work. However, after offering the course several times and expending considerable effort on improving my teaching techniques, certain defects in students' learning persisted. During this time an excellent text, widely adopted in this country, was being used. Thus the search for another source of the difficulty started in my mind.

After some deliberation, I attributed many of the difficulties in students' learning of Mechanics of Materials to the sequence in which we taught the subject and in this paper I shall concentrate on this aspect of the problem.

* Presented before the Mechanics Division at the 58th Annual Meeting of the ASEE, Seattle, Wash., June 21, 1950.

The Basic Methods in Mechanics of Materials

Every subject has a definite technique of its own which must be applied in solving its problems. For example, in applied mathematics, the formulation of a differential equation based on considerations of an infinitesimal element dominates the picture. Thence the problems reduce to manipulation for solving these differential equations subject to the prescribed boundary conditions. Precisely the same kind of problems occur in the mathematical Theories of Elasticity and Plasticity. However, the same procedures do not apply to Mechanics of Materials, or Technical Elasticity.

The dominant technique employed in Mechanics of Materials consists of passing a section through a body in equilibrium, finding a system of statically equivalent forces required to maintain the portion of the body in equilibrium at the section, and finally, with the aid of established formulae, finding the stresses or deformations. This process is repeated over and over in the usual first course of Mechanics of Materials. Yet in teaching, as in many texts, this procedure does not stand out clearly.

A Plan for Revision

Postulating that anything can be mastered by an intelligent student if it is repeated often enough, it occurred to me that unknowingly this principle is frequently violated in teaching Mechanics of

Materials. In nearly every text-book of Mechanics of Materials used in America, in the beginning of the course students' attention is directed in quick succession to several different concepts of the subject. Thus, along with the study of the effect of axial forces on members, statistically indeterminate problems usually are introduced. With rare exceptions, exposition of riveted joints follows. Then frequently torsion is treated, followed by shear and moment diagrams, the latter preceding the Theory of Flexure. In such a sequence of topics the thread of continuity is broken several times. An opportunity for emphasis and mastery of the basic method of approach is lost. Before a student masters even one fundamental concept, he is already studying the next.

I do not claim to have a complete solution to remedy the above situation; the speed with which we cover the material is an important factor. However for the same coverage, an improvement in the existing situation can be obtained. An alternate sequence of presenting the subject offers a definite advantage.

The necessary modifications in the sequence of teaching Mechanics of Materials seem almost self evident. Statically indeterminate problems, which in a first course on Mechanics of Materials are analyzed on the basis of deformations, should come after the student has had as much experience as possible in computing deformation of members. Likewise, the topic on riveted joints, while not difficult, is based on so many assumptions that it too can be treated more adequately in the later portion of the course. A thorough treatment of shear and moment diagrams early in the course diverts attention from the fundamental method of sections used in Mechanics of Materials.

With great care, the foregoing ideas were incorporated into a revised sequence of assignments in two of our sections of about fifty students each in 1948. We continued to use the same text as before. Another instructor and I taught the sections with the revised sequence of topics and the results appeared to be highly encouraging. In the fall of 1948 our findings were reported to all faculty members who were teaching Mechanics of Materials with a suggestion to try the new scheme on a voluntary basis. Our hand was strengthened by the appearance of two newly published books using a somewhat similar arrangement of topics, indicating that others also were not completely satisfied with the status quo. At that time a majority of the instructors agreed to use the new sequence. Last semester all instructors in Mechanics of Materials followed the revised sequence of topics in teaching this course. As the semesters passed by, revisions were introduced into the program. Now, I believe, a rather effective and distinctive program has evolved.

Present Sequence of Topics

The course is started by giving the students a bird's eye view of the subject with particular emphasis being placed on the forces that are necessary to maintain equilibrium at any section of a member. At such a section the forces are interpreted as an axial force, a torque, a bending moment and a shear. As a detailed investigation of the effect of these forces on material can not be discussed all at once, the students are told that these forces will be examined one at a time in the order named. If only one of these forces is necessary to maintain equilibrium as a section, a solution follows directly. However, if several such forces are present, their effect is investigated individually and the results are superposed.

From the above it is seen that in the beginning we attack the problem of stress and strain distribution at *a* section. Attention is confined to statically determinate cases. As usual, first the axially loaded members are analyzed by cutting a section through the member and finding the force necessary to maintain equilibrium, and stresses are determined. This is followed with torsional problems where again the torque necessary for equilibrium

is found at a section, and stress analysis follows. Then, with a mere mention of shear and moment diagrams, the flexural theory of beams is studied. This again is accomplished by cutting sections and determining the bending moments and shears. After this, superposition of direct and flexual stresses at a section are considered. Here again the method of sectioning is employed. This is followed by situations where shearing, flexural, torsional and axial forces exist at a section simultaneously. This completes the study of stresses on the section. Mohr's circle and failure theories then are introduced.

All of the above topics are extremely similar. In every instance reactions are computed first, a section is passed through the body, strain distribution is assumed and the stresses computed. Much reiteration is possible. Each one of these topics strengthens the one treated earlier and prepares the groundwork for the next one. We find that the students have no difficulty in remembering the few formulae encountered in this work.

Critical sections for axial and torsional members, as well as their deformations are treated simultaneously with the above.

After this portion of the course is completed, the emphasis shifts to design. Pressure vessels are discussed. The students already have an appreciation of the principal stresses at this point of the course, which is highly desirable. Next, various beams are designed by extending the previous investigations to many sections, i.e., shear and moment diagrams are utilized. Much drill in constructing these diagrams is given. While shear and moment diagrams are studied, students are already prepared to design beams, which now require negligible expenditure of time. Knowledge of principal stresses is also very valuable for complete comprehension of the problem.

Beam deflection problems are treated next, first rather lightly by the "double integration" method, and then very intensely by the moment-area method. The moment area method in this sequence finds itself in close proximity to the study of shear and moment diagrams.

After completing the study of beam deflections in our first course on Mechanics of Materials, we introduce statically indeterminate problems. The same philosophy is applicable to all of these problems and all types of these problems are handled simultaneously. At this time the students have a much better appreciation of deformations. They are able to attack the indeterminate problems with much greater confidence. Only problems indeterminate to the first degree are considered in our first course.

We conclude the course with work on columns and a discussion of riveted connections.

Conclusions

Although we use a standard text and must jump around in it a great deal in order to follow this sequence, the results are very satisfactory. The sequence of topics appears logical to the students and from my own experience I know that at the end of a semester they can solve much more difficult problems than they could formerly. On comparable examinations, the average percentage grade has increased 10 to 20%. In addition, as a by-product of this system, many of us find that the students' knowledge of statics is also improved.

We at California are convinced of the merits of this new sequence of teaching the subject. I heartily recommend trying it in your own classes. However, before attempting such an undertaking, be sure that you are completely permeated with the philosophy of this scheme. Also some care must be taken in assigning problems from the usual texts.

Acknowledgments

No innovation of the character discussed above can succeed without support from one's own colleagues. I had such support from numerous men of our fac-

ulty. Professors C. T. Wiskocil and H. D. Eberhart encouraged the trial. Professor J. W. Kelly nodded approval, while the younger members of the staff gave it a real try. Among these Professors B. Bresler, R. W. Clough, T. Y. Lin, Messrs. G. W. Brown, F. N. Finn, R. Green, J. H. Jones, A. Olitt, D. Pirtz, K. S. Pister, M. Polivka, A. Scordelis and J. W. Shupe contributed much advice and enthusiastic support for which I am deeply grateful.

Thermodynamics Summer School

June 28–July 7, 1951, Michigan State College

A Summer School in Thermodynamics will be held at Michigan State College, East Lansing, Michigan, June 28–July 7, 1951, at the close of the Annual Meeting of the ASEE. Methods of better teaching of the elementary thermodynamics will be presented as well as modern developments in the field of thermodynamics and a little on advanced theory. In addition, more background material for the teacher will be provided.

The following is a tentative program: June 28, "Leading the Student of Thermodynamics to Think," "Teaching the Concept of State Properties, Boundaries, Systems, etc."; June 29, "First Law of Thermodynamics," "Effective Presentation and Modern Approach to the Second Law of Thermodynamics," "Energy Transfer from the Laws of Thermodynamics," "Fluid Mechanics and Thermodynamics"; June 30, "Availability and Reversibility," "Mathematical Approach to Kinetic Theory of Gases," "Kinetic Theory of Gases and Thermodynamics"; July 2, "Basic Physical Chemistry for Thermo Teachers," "Physical Chemistry and the 1st and 2nd Law of Thermo," "Integration of the Physical Chemistry Approach to Thermodynamics"; July 3, "Visual Aids in Teaching Thermodynamics," "The Atomic Age: How to Equip Engineering Students for It," "Thermodynamics of Gasoline Engine Cycles"; July 4, "Thermodynamics of Vapors: Preparation of Vapor Tables"; July 5, "Combustion Theory: Combustion in Stationary Boilers," "Steam Turbines and Power Plant Design"; July 6, "Theory of Jet Engines," "Combustion in Jet Engines"; July 7, "Gas Turbine Design," "Compressor Design," "Compressor Flow."

A registration fee of $10 will be charged.

On Sanitary Engineering Education

By GEORGE W. REID

Associate Professor of Sanitary and Public Health Engineering, University of Oklahoma

and ROBERT T. TINDAL

Assistant Professor of Civil Engineering, University of Miami, Florida

The scope of the field of sanitary engineering has broadened to such an extent that a re-evaluation of the educational requirements has become essential. The older idea that sanitary engineering included only the fields of water supply, sewage disposal, and stream pollution made the planning of a good curriculum relatively simple. A basic engineering course of study, preferably civil or chemical, with electives in the three fields referred to above, was considered adequate and could be accomplished in the regular four-year undergraduate program. Today, many other activities have been added, including vector control, sanitation, housing, milk and food, and air pollution. To this list should be added the newly developing field of health-physics. The list continues to grow as environmental health problems attract engineering services, and the planning of a satisfactory curriculum has become quite difficult.

Educational Studies

Sanitary engineering curriculum planning has concerned educators and public health officials for the past twenty-five years. Their interest has become increasingly intense in recent years paralleling the horizontal expansion of the sanitary engineer's activities. Mendelsohn and Miller (1)(2)(3) in 1924, 1929, and 1939 reported on the current practices in sanitary engineering and traced its expansion to numbers of schools of engineering and public health. With the advent of World War II, sanitary engineering was taught in engineering schools as an offshoot of civil engineering and in public health schools as public health engineering (4). According to the American Public Health Association report, thirty-nine engineering schools and eight public health schools were following this procedure. The earlier water and sewage sanitary engineering taught in civil engineering departments was resisting incorporation of the broader engineering activities of the sanitary engineer, while the public health schools were developing curricula for engineers to be utilized in environmental sanitation. A serious cleavage developed between these two groups and, for that matter, a residual still exists, though much has been done to shorten the gap between these two schools of thought. This is shown by the Straup report (5) in 1945, which indicates a broadening of engineering curricula, and Ingram report (6).

Since the war a great deal of study has been accomplished, including an excellent report by the Sanitary Engineering Committee of the ASEE (7). The general emphasis in this curricula study developed into a five-year program with a division of opinion whether or not the fifth year should be professional work or that the entire program should be integrated through the five years and that recruiting of students should be developed at the freshman level. Reid (8), Wolman, and Geyer (9) preferred a professional year, while Gotaas (10) and Howland (12) preferred full integration. Several new basic ideas were introduced

into sanitary engineering education, including training of all engineers in sanitary engineering ("Preventive Medicine") by Reid (14)(15) and addition of field training to the curriculum as envisioned by Sheppard, Tisdale, and Reid (16)(17)(18)(19). Industrial hygiene was integrated into sanitary engineering curriculum by Reid at Georgia Tech. (20), and health-physics was presented by Reid and Moeller (21) to the ASEE in 1949. Ingram (23) developed a comprehensive program of training evaluation from the study of career sanitary engineers.

Sanitary Engineer

The term "Sanitary Engineering" was defined by the Committee on Sanitary Engineering of the National Research Council, October, 1943, as:

The professional occupational title "Sanitary Engineer" shall apply to a graduate of a full four-year, or longer, course leading to a bachelor's, or higher, degree at a college or university of recognized standing with major study in engineering, who has fitted himself by suitable specialized training, study, and experience (a) to conceive, design, direct, and manage engineering works and projects developed, as a whole, or in part, for the protection and promotion of the public health, and (b) to investigate and correct engineering works and projects that are capable of injury to the public health by being or becoming faulty in conception, design, direction or management. The practice of Sanitary Engineering includes the following activities: (a) Surveys, reports, designs, direction, management and investigation of:

(1) Waterworks or sewerage systems and closely related engineering structures.
(2) Projects relating to stream pollution, insect and vermin control or eradication, rural and camp sanitation, housing sanitation, and milk and food sanitation.
(3) Systems for the prevention of atmospheric pollution or the control of indoor air, especially the air of working spaces in industrial establishments (industrial hygiene engineering).

(b) Professional research and laboratory work supporting the activities listed in (a).
(c) Responsible teaching of sanitary engineering and closely related subjects in colleges or universities of recognized standing.

Ehlers, Ballard, and Ingram have emphasized the environmental phases (22)(23).

The Sanitary Engineering Committee, *Civil Engineering Division, American Society for Engineering Education*, in its report of June 22, 1949, suggests the following four classifications of sanitary engineering activities (13):

(1) Design and construction of facilities.
(2) Operation—primarily of water, sewage, and industrial waste disposal plants.
(3) Public Health—including all sanitation controls sponsored, initiated or conducted by public and private agencies.
(4) Industrial Hygiene — specialized operations concerning the engineering control of industrial environment.

Obviously, no one undergraduate course of study can adequately prepare a student in all four branches of the field. Actually the only solution appears to be a reversion to the basic subjects and disciplines with a de-emphasis on vocational training.

Basic Curricula

A sanitary engineer's education should prepare him for the wide scope of his field by giving him a proper background for work in design, construction, plant operation, sanitation, industrial hygiene,

etc. His education, therefore, should include basic engineering subjects, including mathematics, surveying, structures, fluid mechanics, geology, soil mechanics, elements of electrical and mechanical engineering. Some knowledge of engineering economics, law, contracts and specifications, and public administration, is valuable to an engineer, and should be included as separate courses or incorporated into other courses. Instruction in statistical methods and biostatistics is necessary in a sanitary engineering curriculum.

In addition to these subjects of value to all engineers, chemistry, bacteriology, and biology are essential subjects in the background education of a sanitary engineer. Some knowledge of P. H. administration, vital statistics, epidemiology, entomology, and parasitology is required.

All engineers should possess, and sanitary engineers must possess, the ability to address a gathering and to express themselves clearly, simply, and precisely, both orally and in writing.

To this basic educational background must be added professional education in water supply, sewerage, industrial wastes, stream pollution, and environmental and industrial sanitation. Every sanitary engineer should have a basic knowledge of all of these and advanced work in his field of specialization.

Three months of field training should be a required part of a sanitary engineering curriculum.

Obviously, it is impossible to crowd all of the desired material into a four-year or even a five-year curriculum without forcing out essential basic subjects. A four-year program leading to a B.S. in engineering appears to be essential and should be followed by a fifth year of study to round out the coverage of the various activities of sanitary engineering. Advanced work should be available in specialized fields. The normal doctoral program may be desired in certain cases, but perhaps a professional degree would be better for most students. The objective of a program leading to this degree would be a higher level of professional competence than is required by the program for the master's degree without the emphasis on creative research which is characteristic of a doctoral program. Such a degree is being offered by the Massachusetts Institute of Technology (24).

A civil engineering background preferably with a sanitary engineering option appears to offer the best coverage of the entire field and is definitely recommended for design and construction activities. A chemical engineering background may be desirable for plant operation and either civil, chemical, or mechanical may be adaptable to the public health and industrial hygiene classifications.

Service courses should be offered to students in other departments to give them some realization of the health hazards which their work might create or eliminate. Reid (14) points out many of these possibilities in his article, "Preventive Medicine."

Seminars should be utilized to develop speaking ability and for training in research methods.

Recent Evaluations

Recommendations and criticisms of the sanitary engineering training as now offered were requested from the state health departments of the forty-eight states and from the main and regional offices of the U. S. Public Health Service. The recommendations were remarkable in their agreement and were essentially those made by Professor Dunstan and his committee (7).

There was an almost unanimous request for a broader coverage of the field with less emphasis on water and sewage and more attention to the other activities. This reaction is natural since the work of the state and federal health agencies is roughly 70% environmental sanitation.

The five-year academic training was considered best by most of the correspondents, the first four years leading to a

B.S. in engineering and the fifth year to an M.S. covering the expanded field. Both the state and federal health services prefer this general coverage in the fifth year to a specialization in any one phase dealing in the general principles of applied sanitary engineering (professional training).

They reason:

(1) Only after the man has started to work can he be sure of the branch to which he will be assigned.
(2) He cannot be sure which he will prefer until he has had some experience.
(3) Specialized education can and will be arranged for when needed.
(4) In any case, a public health officer needs to have at least a speaking knowledge of other phases of public health since one can so readily affect another.

Some knowledge of operating problems was requested instead of all theory. Actual experience, obtained by field training, was high on the list of desired background material.

The criticism most frequently made and most avidly discussed was "inability to speak and write English, to make decent reports and to address gatherings." The success of a public health program will frequently depend upon the ability of the engineer to explain the program to the public and his ability to enlist their support and cooperation. Good public relations are essential.

The academic program as proposed by ASEE is apparently as close to that desired by the state and federal health agencies as can be devised.

Field Training

The need for field training has long been felt. The U.S.P.H.S. operates field training programs for its own personnel and has accepted other students. They now propose to set up training centers throughout the country to offer three-month summer field training to public health and sanitary engineering students (17)(18). The training would be given in cooperation with participating universities and would probably be given between the junior and senior years, replacing the surveying camp now offered in many civil engineering curricula. It should be listed as part of the school curriculum and college credit instructional standards should be obtained. This was done at Georgia Tech. in industrial hygiene cooperatively by Georgia Tech., the State of Georgia, and the United States Public Health Service (19). Such an arrangement will supply the field experience requested, and will offer an opportunity for exchange of ideas among students from many places and with varied backgrounds. A problem in one locality may have been solved already in another.

Seminars

The criticism of the graduate's ability to express himself properly, orally or in writing, is a very common one and one which has been observed in many fields other than sanitary engineering. There is no excuse for lack of good basic engineering "know how," which is essential, but the opportunity to put it to use may be lost because of an inability of the engineer to express himself properly. The student should be given the opportunity to present oral reports frequently enough to develop some poise and the ability to state facts simply and concisely, and to maintain the attention of his audience. This might be accomplished by a greater use of seminars, which would also develop an ability to look up the literature in the field. Far too few graduates can write a clear, brief, and orderly report. Certainly some experience in writing in the third person is essential and can be readily worked into present courses. The student should be impressed with the fact that these things have great practical importance.

Conclusion

A sanitary engineering educational program should consist of:

1. A four-year program leading to a B.S. in engineering. In most cases a sanitary option in C.E. is preferred, although in some instances chemical or mechanical engineering may be desirable. Summer field training should be included (probably in place of surveying camp).
2. A fifth year leading to an M.S. and covering the expanded field.
3. Advanced work in the field of specialization.

Discussions of operational problems should be fitted into both the academic studies and the field training work. Advantage should be taken of all opportunities to develop the students' abilities in public speaking and report writing.

REFERENCES

(1) Mendelsohn, Isador W., "Sanitary Engineering Courses of Engineering Colleges in the United States," Public Health Rep. 39, 1989 (1924).
(2) Mendelsohn, Isador W. (same as above), Public Health Rep. 44, 645 (1929).
(3) Miller, Arthur P., "Undergraduate Engineering Training in Public Health and Related Activities in Engineering Colleges of the United States," Public Health Rep. 54, 29 (1939).
(4) Committee on Professional Education of the American Public Health Association and the U. S. Public Health Service: "Employment Opportunities in Public Health," New York, American Public Health Assoc., 1945.
(5) Straup, Conrad P., Ph.D., Sanitary Engineer, Public Health Service, Oak Ridge National Laboratory, Oak Ridge, Tennessee, "Undergraduate Sanitary Engineering Training in the United States," Vol. 64, No. 42, Federal Security Agency, Public Health reports, October 21, 1949.
(6) Ingram, William T., M.P.H., Engineering Field Association, American Public Health Association, "The M.P.H. Program for Engineers," June 16, 1948, ASEE Meeting.
(7) Dunstan, Professor Gilbert H., Chairman, University of Alabama, "Basic Educational Training for Sanitary Engineers, Report of Committee Three, Sanitary Engineering, Civil Engineering Division, American Society for Engineering Education," June 22, 1948.
(8) Reid, George W., "Sanitary Engineering," *Georgia Engineer*, 1949.
(9) Wolman, Abel, and Geyer, John C., "Graduate Curriculum in Sanitary Engineering," ASEE, Troy, 1949.
(10) Gotaas, Harold B., Professor of Sanitary Engineering, University of California, Berkeley, California, "Graduate Study in Sanitary Education," presented to ASEE, June 16, 1948.
(11) Shepard, W. P., M.D., Chairman, American Public Health Association, "Public Health Degrees and Certificates Granted in the United States and Canada during the Academic Year, 1946–47," *American Journal of Public Health*, Vol. 38, No. 1, January, 1948.
(12) Howland, W. E., Dean, Purdue University, "Coordination of Instruction in Sanitary Engineering," *Journal of Engineering Education*, Vol. 24, No. 7, p. 540, May, 1949.
(13) Shepard, M. D., Chairman, Committee on Professional Education, "Education Qualifications of Public Health Engineers," American Public Health Association, *American Journal of Public Health*, Vol. 37, No. 1, Jan., 1947.
(14) Reid, George W., Assoc. Prof. of Civil Engineering, Georgia Institute of Technology, "Preventive Medicine in Engineering Education," *Journal of Engineering Education*, Vol. 37, No. 8, April, 1947.
(15) Stubbs, Trawick, "Educational Factors in the Ultimate Control of Malaria," National Malaria Society, Vol. III, 4, 1944.
(16) Committee on Professional Education (W. P. Shepard M.D., Chairman), American Public Health Association, "Field Training of Public Health Personnel," *American Journal of*

Public Health, Vol. 37, No. 6, June, 1947.
(17) Tisdale, Ellis S., Sanitary Engineering Director, Chief of Training Services, CDC, USPHS, "Supplementary Field Training of Sanitary Engineers for Public Health Careers," prepared for presentation, ASEE, Meeting, Seattle, Washington, June 16, 1950.
(18) Tisdale, Ellis S., (same as above), and Crawford, James H., Sanitary Engineer, Assistant Chief of Training Services CDC, USPHS, "Field Training for Sanitary Engineers and Sanitarians," presented State Sanitary Engineers Conference, Washington, D. C., May 17, 1950.
(19) Reid, George W., and Fehn, Clyde F., "An Industrial Hygiene Graduate program," ASEE, June 16, 1948.
(20) Reid, G. W., and Moeller, D. W., "Impact of Nuclear Physics on Sanitary Engineering," Civil Engineering Bulletin of the Civil Engineering Division, ASEE, Vol. 15, No. 3, May 1950.
(21) Reid, George W., "Education and Training of Industrial Hygiene Engineers." Delivered Austin, Texas ASEE Meeting 1948.
(22) Ehlers, V. M., and Ballard, W. T., "Sanitary Engineering." *Medical Physics*, Vol. II, Chicago, 1950.
(23) Ingram, William T., Engineering Field Associate, A.P.H.A., "A Philosophical Approach to An Integration of Body of Knowledge, Sanitation Personnel and Environmental Control," American Public Health Assoc., 1947.
(24) M.I.T. Graduate School Bulletin, 1950, Boston, Massachusetts.

Summer School
Engineering Drawing Division
June 21-26, 1951

The Executive Board of the ASEE has formally approved sponsorship of the Engineering Drawing Division Summer School to be held in connection with the Annual Meeting at Michigan State College. This will start four days previous to the Society meetings, which is Thursday, June 21, 1951, and conclude with our regular sessions allotted during the following week.

The general theme of this school will be "Improving our Status as Teachers of Engineering Drawing" treated on a basis of:

(a) Meeting curriculum requirements
(b) Teaching methods by lecture demonstrations
   1. Basic Drawing
   2. Descriptive Geometry
   3. Advanced Drawing
   4. Elementary and Advanced Graphics
(c) Industrial applications

The local committee at Michigan State College making arrangements at East Lansing for this Summer School consists of Professor C. L. Brattin, Chairman; O. W. Fairbanks; N. R. Sedlander; R. O. Ringoen (all of Michigan State College); Professor Philip O. Potts, University of Michigan; Professor Ralph T. Northrup, Wayne University; and Dean Jasper Gerardi, University of Detroit.

The Division is planning to exhibit student work in engineering drawing, course outlines, foreign drawings, drawing instruments and materials, visual aids and other displays which will be of interest to engineering teachers.

A cordial invitation is extended to all members of the Society who are interested in this program.

Ralph S. Paffenbarger, *Chairman*
Division of Engineering Drawing, ASEE
The Ohio State University

The Values Inherent in the Humanities

By JAMES R. NAIDEN
Assistant Professor of Humanities, University of Washington

The words *values* and *humanities* require a satisfactory definition. Let us begin with the simpler, the Humanities. The term designates a very wide range of subject matter: the study of numerous languages and literatures, such as Latin and Greek, Italian, French, German, English on five continents, including, of course, American literature. Further, the Humanities usually include the subject of the history of art, dealing with the painting, sculpture, and architecture of all eras, places and climates of opinion. To this we may add musicology and musical appreciation, a subject with vast potential appeal, but not so well developed in this country as art history, being perhaps fifty to seventy-five years behind it. These three, literature, art, and music, are the main structure of humanities today. They constitute the productions of men's minds and hands and feelings from the art of the new stone age to the latest poems of Ezra Pound, some eight thousand years by the smallest calculation, and domiciled on four continents chiefly, but in the widest sense resident every place except Antarctica So many tongues, ideas, governments, philosophies, religions, passions and events are reflected in these works of literature, art and music that no human being can possibly peruse and understand more than a fraction of this material. One large university has 113 specialists giving graduate instruction in the various areas described.

* Presented before a meeting of the Humanistic-Social Division Summer School, Seattle, Washington, June 23, 1950.

From this definition it is clear that our engineering students can never apprehend, in their college years at least, all this subject matter; but that they have acquaintance with some representative parts of it is the desire both of those who are responsible for their education, and of some of the students themselves. This desire for non-scientific knowledge is not present in America alone; in my student days in New York and Paris I knew engineering students from Persia, India, China, Japan, and various countries in Europe, and from them I learned that there is a considerable body of opinion in all those countries that their much more pressing need of technology does not justify, even there, the neglect of art, literature, and music.

Meaning of Value

We now return to the word *value.* A word that covers so much is not easy to define, out of context, with anything like completeness or precision. It is best to proceed by describing the values actually found in the humanities by students of them throughout the world.

The first value that springs to hand is that of pleasure or recreation. Though engineering students are sometimes compelled to acquire a knowledge of these at such a rate as to put stress upon the sterner parts of character rather than upon the aesthetic, the force that produces the literary or artistic work in the first place is *delight.* In a world so troubled as ours, no recreational pursuit needs any defense.

Now what this delight is, is not easy to say. The rhythm of language, of poetry,

of music, or of a fresco causes delight, but for what reason seems to be at present beyond the grasp of psychology, or physiology. Let us look at a particular instance. The student of the humanities who meets, for the first time, the Persian miniatures, the Chinese landscape, the thirty-six views of Fujiyama, is likely to be filled with feelings of a mixed sort: of surprise at the coloring, of amusement at the naïveté or freshness of the artist's viewpoint, of speculation at the effectiveness of the strange system of perspective, of sympathy for the vicissitudes of human experience so recorded and so understandable despite a gap of geography and time between the onlooker and the artist. One's delight on looking at larger masterpieces, such as the Pieta of Michelangelo in the Cathedral of Florence, the view of Toledo by El Greco, or the landscapes of Poussin, is different; he here is inwardly cowed by the magnificence of the artist's imagination, by the haunting power of these lines and colors, by the tremendous technique, of which only the last is really easy to analyze.

I have chosen my examples of delight largely from the art of painting, but of course there is equal delight to be found in literature and music. That derived from music is especially difficult to put into words; hence, if we must express in words what value is to be found in the humanities, the area most amenable to our purpose would be literature, the art of words *par excellence*. Here we may observe the effects of rhyme, and rhythm, and the unleashing of the power of association in the reader by the use of famous names. Nowhere in literature is the power of a mere name to excite over powering emotions more clearly told than in the writings of De Quincey, as he relates the panoramas of his opium dreams and that thunderous Latin phrase that gives the whole experience its origin. For simple tastes, the delight of literature may be that of a successful story, of suspense in other words; or of the idealization of character; or of vicarious delight in the way the hero achieves a goal which the reader can only attain through the symbol of literature. For the erudite Latinist, the half-literate reader of detective stories or the illiterate Kashgari tribesman in the mountains of Western Persia, literature is a thriller.

Now some one may say, If literature is so delightful, why does it have to be *taught?* Why do we have to force it down? And one may answer, that these values are not instinctive. One *learns* to appreciate a Persian miniature, a Japanese print, a Spanish painting; the Persian nomad child learns to cry at the sonorous rhythms of the *Shah-nameh* recited beside a campfire by observing the tears running on the faces of his elders. Such appreciation of art, and the manner of expressing appreciation is picked up from the environment, and in our culture, the school is the place where such things are often taught. Households wherein the Persian poets, the Italian painters, the sonnets of Shakespeare, and the writings of Jefferson are not a part of the life, may send their children to the universities or the secondary schools, where the government, inscribing on the first reader the verses, or the image of the great artist in the humanities, acquaints the budding personality with the fact that this poem, painting, or musical phrase is somehow what men take delight and pride in, and must labor to appreciate, preserve, and transmit to oncoming generations. Appreciation of the fine arts is not instinctive; it is part of what the anthropologists call acculturation, the leading of the new life into reasonable conformity with established standards of language, manners, courtship, government, military proficiency, religious orientation, and, what is of concern to us, of appreciation of the recreational art and the way of life as symbolized by such typical humanistic expressions as the music of Germany and Italy, the poetry of Japan and China, the multifarious paintings of Mexico and America. Whether at home, at school, or in the

university, the appreciation of the fine arts must be inculcated, literally, must be taught, directly or indirectly. If mathematics must be taught, humanities must be taught, and in part for the same reason, not merely for uniformity of expression, not even for orthodoxy, but because the humanities are what they are because of an acculturation process going back for ten or twenty thousand years. To participate in this thing, one must labor, study, attend, have emotions, repeat the experience, follow others, until the process is reasonably complete—in other words, one must be educated.

Scope of Humanities

So far we have arrived at this: the humanities are the total of the works of art, literature, and music of the world, and more significantly of human appreciation of them, which appreciation has to be somewhat laboriously acquired through a period of education.

And what is the good of this knowledge and these attitudes if we get them? Are these pleasures any better than those a person without them might have? What good does this knowledge do that the knowledge of social sciences and mathematics and natural sciences would not? What value is there, to repeat the title of this paper, inherent in the humanities that is peculiar to them, and exactly how does it benefit those who attain it?

We have spoken of the delight that one learns to feel from the contagion of our fellows. In the next place, one must place the *immediacy* of the humanities. The artist and the onlooker are in direct, or almost direct communication. In the case of a phonograph record of Frost reading his own poetry, the contact is about as direct as it could be. In the case of the student who approaches the masters of delight through the mediation of a commentator, virtuoso, or editor, the immediate contact between artist and onlooker is supplemented by that of a teacher whose function it is to increase the bonds between artist and onlooker. As an example of immediate contact, the present speaker has looked at the paintings of El Greco, just, or almost just, as they stood when the last brushmark was completed; at the statuary of Michelangelo as he left it; at the Perseus of Cellini just as he made it. The words of Homer, Lucretius, and Milton he has heard approximately as they were originally spoken. With such personal communication from the great of other times, one can do as he pleases. One can, in the proper company, reuse the original phrases to enamel one's own rough expression; one can appropriate the feelings of the sensitive and observant and experienced to one's self. The irreligious can share, for a while, the inner life of the Trappist monk; the unverbalized student can reproduce, as he reads the *Apology,* the unequalled fluency of Plato; the helterskelter mind can temporarily attend to the point with the precision of an Aquinas. Lack of expressive power fetters the young, as we all know; and likewise even the perfect mastery of one language does not begin to suggest the expressiveness and precision of other tongues and cultures.

The perusal of these masters of expression or of word, line, color, or phrase repays in the increased ability to define to one's own self what one wants, and the price one is willing to pay to get it. The self-knowledge of a Socrates adds to the self-knowledge of a twentieth century student of engineering. The self-knowledge of the Chinese landscape painters will teach us a good deal about what one can think about the natural grandeurs of the National Forests thirty miles east of Seattle, and may help to settle in someone's mind just how much social cost it is worth to keep them from a predatory economic environment. The self-knowledge of St. Augustine's *Confessions* may jar the conceit out of some of our sophomores, or out of ourselves, the latter being the case more probable than the former. So thus we may know

ourselves, and be verbally precise about it, after a study of the humanities.

Self-Knowledge and Self-Expression

But in a day of group action such as ours, the educational value put upon subjects devoted to self-knowledge and self-expression is generally less than that put upon those which are conducive to the good of groups. Thus in our day medicine, engineering, economics, and social work are academic areas of great distinction; oriental literature and the classics are in the caretaker stages. One may properly ask, what value have the humanities for the times we live in?

Our times are cosmopolitan. Our universitiy faculties are international as they have not been since Latin ceased to be a universal language. Our plans for national defense embrace a dozen other countries, many of them quite alien to ourselves in heritage and outlook. At the highest level in the government of men, in science, as well as in literature, the lines of communication are international, yes, global. The leaders and the followers of the next generation must not be provincial. Just as the intellectual preeminence of the ancient Greeks over their contemporaries is believed to be the result of their contact with many races and climates of opinion, just so the present preeminence of the English-speaking cultures may rest in part upon the wide and deep contact with foreign cultures, in war, in peace, in the school. in the art museum, in the concert hall, as teachers and students, engineers and experts, travelers and writers. For an international future, an international type of education must surely be one of the foundations.

No more dramatic proof of the value of the humanities for the international world we live in can be cited than the opposition to them by a recently deceased but well-known German politician, and the present rulers of the Communist third of the earth. There is no place for a sympathetic understanding of other times and places, for the personal, individual, sympathetic development that the humanities stand for. The aim of those societies most of us take to be the destruction of the world of differing cultures, and the exaltation of one particular way of life. For the analysis of such nonsense as is solemnly promulgated by these people and for a ready perception of the real dangers, there is no restorative so helpful as a knowledge of the facts of history, art, and literature, with which such grand lunacy may be seen in its real perspective. That a world can be shattered by new ideas, the student of humanities knows from his study of the effect of Christianity upon classical pagan culture. How potent new ideas can be he knows from his reading of Voltaire. That a heroic action can arrest the dynamics of such a movement, he knows, too. That the reaction can prove deadlier than the danger it confronted, he knows from the history of Sparta, and the intellectual silence that brooded over the plains of that automatic country. That all is not lost if the government is lost, he has learned from the Consolations of Boethius. With experience, perspective, and knowledge, the student of humanities is fit for the strenous international contest that lies before us. And in the local arena the humanities will prepare him also. He who has read the poignant *Forty Days of Musa Dagh* and the terrible *Os Sertoes* will have some idea of how *not* to deal with our curious neighbors, the Doukhobors, who carry out the will of God by dynamiting railroad trestles and burning their own houses, to say nothing of stripping naked in the courts of the otherwise conservative province of British Columbia.

For the extension of one's experience beyond one's own lifetime; for the comprehension of other personalities; for the quick acculturation into the life of our friends and enemies, the humanities and the social sciences go hand in hand. The social sciences are concerned in the main with the record of groups; the humani-

ties in the main, with individuals. In a time such as ours, when each one thinks of himself both as a member of groups and as an individual, both subjects are indispensable.

But let me summarize, now, what has been said. The humanities are man's artistic, literary, and musical activities; they include the learned patterns of appreciation to them and they further self-knowledge and self-expression, while at the same time furthering our knowledge of and ability to work with or in foreign cultures.

Summer School
Humanistic Social Division
June 21-23, 1951

The Humanistic-Social Division of the ASEE is now making plans for its summer school to be held at Michigan State College in June immediately preceding the regular meetings of the Society. The summer school will be held June 21, 22, and 23rd, and the Divisional meetings of the regular session will be on June 25 and 26. Anyone interested, therefore, can attend both the summer session and the regular Division meetings in a period of six days.

The past two summer schools have been devoted to consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering. All of those who have attended have felt that this interchange of ideas and discussion of common problems has been well worth while, and it is hoped that this year's session will be as valuable as the past two have been.

All members of the Society are cordially invited to attend any or all of the summer school sessions and to participate in the discussions. Anyone who is interested in attending or who has a problem he would like to present is urged to write to Dr. John W. Shirley, North Carolina State College, Raleigh, North Carolina. Further information will be published in the JOURNAL as soon as it is available.

Library Identification with Teaching and Research

Abstract of Report, Executive Committee, Engineering School Libraries Committee, 1950–51

The library as an admitted force in learning, teaching, and research activities is a rare phenomenon in educational institutions concerned with science and technology. The problematical situation of apathy toward library utility in educational institutions devoted to science and technology has prompted certain observations and arguments:

1. Time and efficiency, which are so important to the success of any engineering endeavor, too often are sacrificed where even a small amount of literature-searching skill on the part of the investigators would have saved both.
2. The ability to find information quickly can be an asset of high economic value. Acquired through ordinary powers of analysis, such ability will be found to be of measurable gain from the first year of college through an engineer's entire career.
3. The potentialities of library techniques and resources are seriously overlooked by the studying, the teaching, and the practicing engineer alike.

Believing that no library exists, nor can exist for its own sake, nor in a vacuum, nor as a mere formal requirement, the Engineering School Libraries Committee of the ASEE is undertaking a long-range study of the essentials of vital library service in science and technology. The Committee's statement is intended to indicate the broad lines along which its members are planning to proceed, looking toward common recognition of the library as a dynamic in high-level student learning, in best teaching and in successful research.

To implement its program, the Committee is attempting to develop active Engineering School Libraries groups in all ASEE Sections. Section Chairmen have been asked to assist by appointing Section ESL Committee Chairmen from lists of librarians in their regions. It is suggested that the membership of the Section ESL Committee consist not only of librarians, but also of faculty members in the region. The Section ESL Committee will confine its action to discovering, in its region, what is required of library service to achieve integration with teaching and research, and thereafter develop techniques for implementing such integration. Since these things involve the views and opinions of teachers, ESL meetings must include them and not be conducted as librarians' discussion groups.

In general, librarians in engineering and science school libraries are being urged to identify themselves with the work of the ASEE in all of its ramifications; to accept and seek membership on various ASEE Committees, and in other ways come to know the requirements of teaching and research as expressed by the various Divisions and Committees of the ASEE; and, importantly, to become known as an agent and source of aid in all professional activities of the ASEE and of its individual members.

Restated, the Committee's overall aim is this: to effect recognition of the library as a coordinate agency of education, with as much responsibility and significance in teaching and research as any department of instruction; an objective whose realization depends directly upon acceptance of responsibility by the individual working librarian.

EXECUTIVE COMMITTEE,
ESL Committee, ASEE

Johanna E. Allerding
W. R. Harvey
Philip Leslie
John B. O'Farrell
David A. Webb
Edward A. Chapman, *Chairman*

A New Nomographic Treatment of the Cubic

By C. R. WYLIE, JR.
Chairman, Department of Mathematics and Astronomy, University of Utah

In many engineering problems one of the important details is the numerical solution of a cubic equation. In addition to the exact, but cumbersome, formulas for the roots of such an equation, there are many well known methods of approximate solution, but in spite of this it seems appropriate to call attention to still another. Since the following graphical treatment of the general cubic was first suggested by work in applied differential equations, and probably finds its greatest usefulness in this field we shall develop it from this point of view.

Suppose, then, that we are interested in the linear differential equation with constant coefficients

$$a_0 \frac{d^3z}{dt^3} + a_1 \frac{d^2z}{dt^2} + a_2 \frac{dz}{dt} + a_3 = 0. \quad (1)$$

In the usual problem in dynamics or in governing, the a's will all be positive, but the applicability of our method does not depend upon this fact. As a device to reduce the number of parameters with which we must deal, let us make the proportional change of independent variable

$$t = \left(\frac{a_0}{a_3}\right)^{\frac{1}{3}} T. \quad (2)$$

This reduces the given equation to the simpler, dimensionless form

$$\frac{d^3z}{dT^3} + U\frac{d^2z}{dT^2} + V\frac{dz}{dT} + 1 = 0, \quad (3)$$

where

$$U = \frac{a_1}{a_0}\left(\frac{a_0}{a_3}\right)^{\frac{1}{3}} \text{ and } V = \frac{a_2}{a_0}\left(\frac{a_0}{a_3}\right)^{\frac{2}{3}}.$$

Under the substitution (2) the characteristic equation of (1) is transformed from

$$a_0 s^3 + a_1 s^2 + a_2 s + a_3 = 0 \quad (4)$$

into

$$S^3 + US^2 + VS + 1 = 0. \quad (5)$$

In other words, the change of variable (2) in the differential equation is equivalent to the change of variable

$$s = \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}} S$$

in the characteristic equation. Hence if $S = r$ is a root of (5), then

$$s = \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}} r \quad (6)$$

is a root of (4).

It is worth noting that the coefficients U and V can be computed from the original coefficients a_0, a_1, a_2, a_3, by a simple slide rule calculation. Hence as a starting point for a practical method of solution, (5) is to be preferred to the more usual reduced form of the cubic

$$S^3 + \alpha S + \beta = 0$$

obtained from (4) by the relatively complicated algebraic process of eliminating the term in s^2 by the substitution

$$s = S - \frac{a_1}{3a_0}.$$

By means of the useful identity

$$A\phi_1 + B\phi_2 + \phi_3 \equiv \begin{vmatrix} A & 1 & 0 \\ B & 0 & 1 \\ \phi_3 & -\phi_1 & -\phi_2 \end{vmatrix}$$

we can write (5) in the form

$$\begin{vmatrix} U & 1 & 0 \\ V & 0 & 1 \\ -(S^3+1) & S^2 & S \end{vmatrix} = 0. \quad (7)$$

Hence the construction of a nomogram from which the real roots of (5) can be read is now hardly more than a routine matter.

However, before we can display (7) as an alignment chart in the ordinary cartesian plane it is necessary that the last column in the determinant consist entirely of 1's. There are of course infinitely many projective transformations which will accomplish this, but if we desire to keep the scales of U and V uniform, as is certainly natural, our choice is severely limited. In fact there are essentially only two possibilities: we may either add the elements of the second column to the corresponding elements in the third column, or we may subtract them. The first alternative leads at once to

$$\begin{vmatrix} U & 1 & 1 \\ V & 0 & 1 \\ -\dfrac{S^2-S+1}{S} & \dfrac{S}{S+1} & 1 \end{vmatrix} = 0. \quad (8.1)$$

The second leads similarly to

$$\begin{vmatrix} U & 1 & 1 \\ -V & 0 & 1 \\ -\dfrac{S^3+1}{S^2-S} & \dfrac{S}{S-1} & 1 \end{vmatrix} = 0. \quad (8.2)$$

In each case U and V are represented by uniform scales on the lines $y = 1$ and $y = 0$, respectively. In (8.1), S is read from a cubic curve graduated according to the parametric representation

$$x = -\frac{S^2-S+1}{S}, \quad y = \frac{S}{S+1}.$$

In (8.2) the scale of S is defined by the parametric equations

$$x = -\frac{S^3+1}{S^2-S}, \quad y = \frac{S}{S-1}.$$

The nomogram corresponding to (8.1) is shown in Fig. 1. Since in most applications, U and V turn out to be small positive numbers, it is evident that the important range $S < 0$ is adequately covered except for values in the neighborhood of $S = -1$. One interesting feature of Fig. 1 which is not strictly a part of the nomogram is the semi-circular arc which partially surrounds the origin. This is the envelop of the lines joining positive values of U and V such that $UV = 1$. Now the stability criteria for the solutions of a differential equation such as (1), i.e., the conditions that each root of the characteristic equation (4) have negative real part, are that all coefficients be positive and that

$$a_1a_2 > a_0a_3.$$

Hence it is clear that all roots of (5), including the complex roots not given by the nomogram, will have negative real part when and only when U and V are positive, and when in addition, the line joining U and V does not intersect this arc. If the coefficients a_0 and a_3 are of like sign (so that the roots of (4) have the same sign as the roots of (5)) this ensures that all solutions of (1) are stable.

A nomogram based on (8.2) would have the general appearance of Fig. 2. However, since Fig. 1 adequately represents Equation 5 except around $S = -1$ we have drawn only the portion of this second nomogram shown in Fig. 3. Of course after the roots of (5) have been found from Figs. 1 and 3, (6) gives the roots of the original equation, (4).

In many applications it is unnecessary to know the complete solution of (1), for all that is required is a knowledge of how fast the transients represented by this solution will decay. For the solution corresponding to the real root or roots of (4), this rate of attenuation can be found immediately. However for the oscillatory transient corresponding to a pair of complex roots of (4) the situation is not quite so simple. If the characteristic equation has a pair of complex roots we

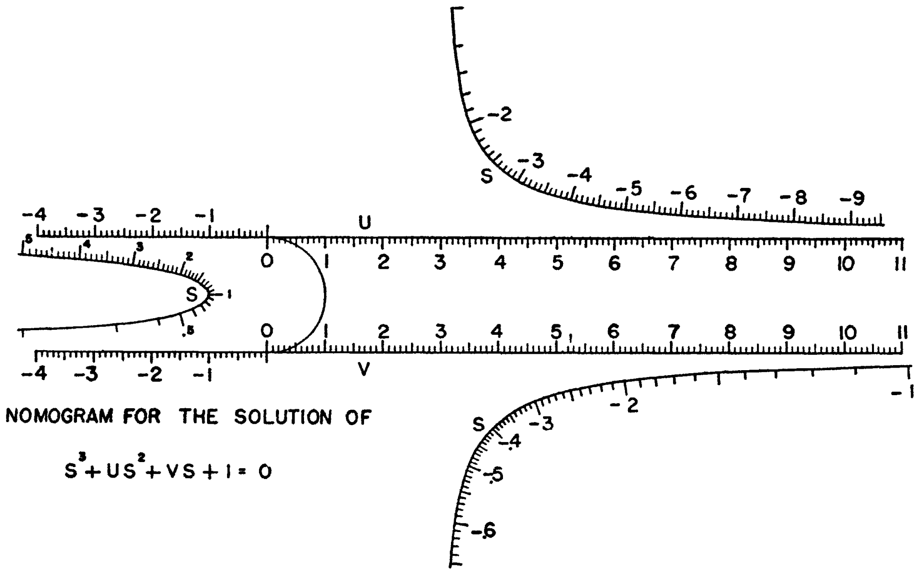


FIG. 1.

can of course solve for them explicitly from the quadratic equation remaining when we divide out the linear factor corresponding to the one known real root. With the complex roots known, the rate of attenuation of the coiresponding transient can easily be determined. On the other hand it is probably more convenient to proceed as follows.

Consider the second order differential equation

$$mz + c\dot{z} + kz = 0, \qquad (9)$$

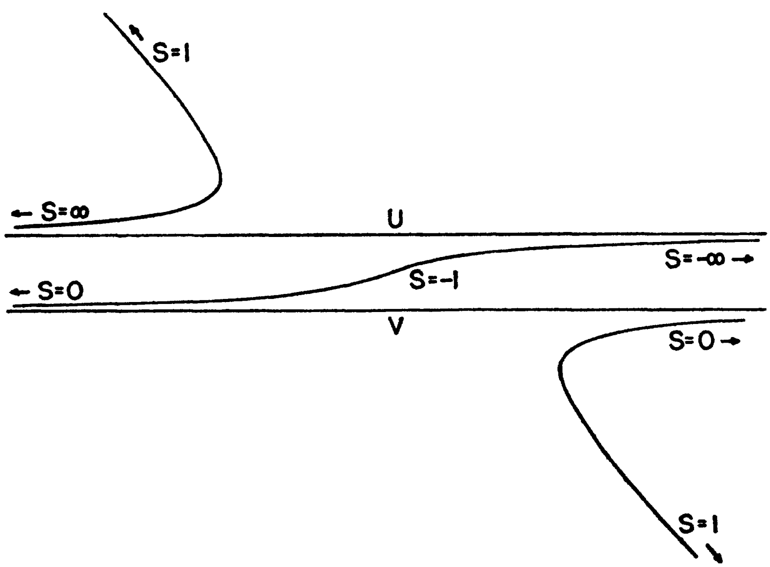


FIG. 2.

whose characteristic equation we suppose to have roots

$$-p \pm iq$$

The undamped natural frequency of the behavior described by this equation is of course

$$\omega_n = \sqrt{\frac{k}{m}}$$

and the critical damping (or its equivalent) is

$$c_c = 2\sqrt{km}.$$

Hence we can write (9) in the form

$$z + 2\frac{c}{c_c}\omega_n z + \omega_n^2 z = 0$$

Comparing this with the equivalent form

$$z + 2pz + (p^2 + q^2)\,z = 0$$

it is clear that

$$R \equiv \frac{c}{c_c} = \frac{p}{\omega_n} \text{ and } \omega^2_n = p^2 + q^2$$

Hence the damping ratio, or fraction of critical damping actually present (which is a convenient and conventional measure of the rate at which the solution of (9) will decay) is expressed in terms of the roots of the characteristic equation of (9) through the formula

$$R = \frac{p}{\sqrt{p^2 + q^2}}. \tag{10}$$

Obviously the foregoing analysis can be applied to any differential equation whose characteristic equation has one or more pair of complex roots, the oscillatory solution corresponding to each pair of complex roots being characterized by its own particular damping ratio, R. Specifically, if the roots of the characteristic equation of (1) are $-p \pm iq$ and $-m$, it is possible to compute the damping ratio of the one oscillatory component without actually finding the complex roots. To show how this can be done, we first observe that if the roots of (4) are $-p \pm iq$ and $-m$, then the roots of (5)

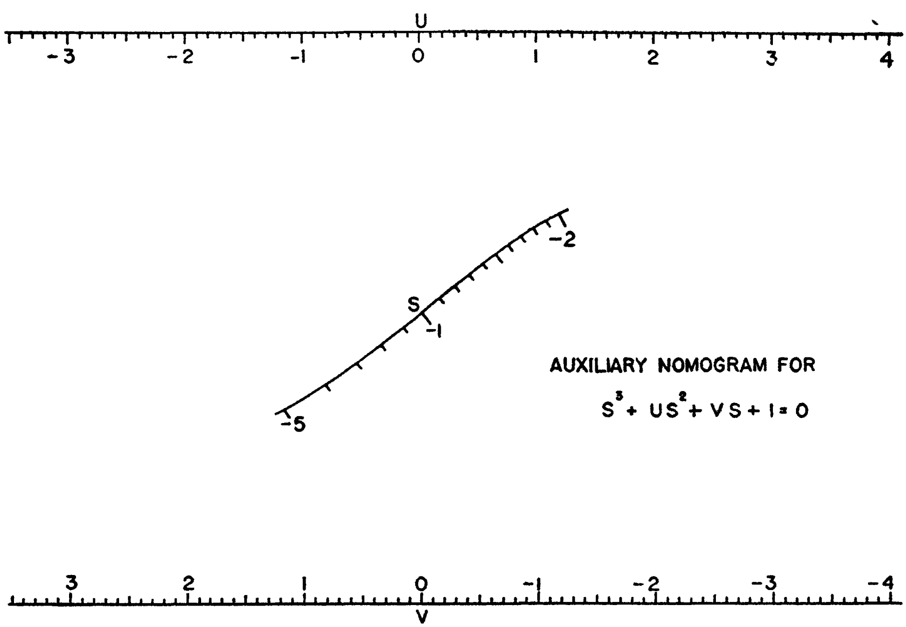


FIG. 3

are

$$- P \pm iQ = (- p \pm iq) \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}}$$

and

$$- M = - m \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}}.$$

Hence

$$\frac{p}{\sqrt{p^2 + q^2}} = \pm \frac{P}{\sqrt{P^2 + Q^2}}$$

the plus sign being taken if a_0 and a_3 are of like sign and the negative sign if a_0 and a_3 are of opposite sign. Thus R can be computed equally well from the roots of (4) or from the roots of (5).

Now using the well known relations between the roots and coefficients of a polynomial equation, we have from (5)

$$U = M + 2P, \qquad (11)$$

$$V = 2MP + P^2 + Q^2, \qquad (12)$$

$$1 = M (P^2 + Q^2). \qquad (13)$$

From the first and third of these equations we have

$$P = \frac{U - M}{2} \text{ and } P^2 + Q^2 = \frac{1}{M}$$

and so

$$R = \frac{P}{\sqrt{P^2 + Q^2}} = \left(\frac{U - M}{2}\right) \sqrt{M}$$

or

$$U - M - \frac{2R}{\sqrt{M}} = 0. \qquad (14)$$

Similarly, eliminating P and $(P^2 + Q^2)$ from (12) by using the relations

$$P = R \sqrt{P^2 + Q^2} \text{ and } P^2 + Q^2 = \frac{1}{M}$$

we have

$$V - \frac{1}{M} - 2R \sqrt{M} = 0. \qquad (15)$$

Either (14) or (15) furnishes a simple formula for R, provided that the real root, $- M$, is known. Since $- M$ can always be read from Figs. 1 and 3, the damping ratio R can thus be found with-

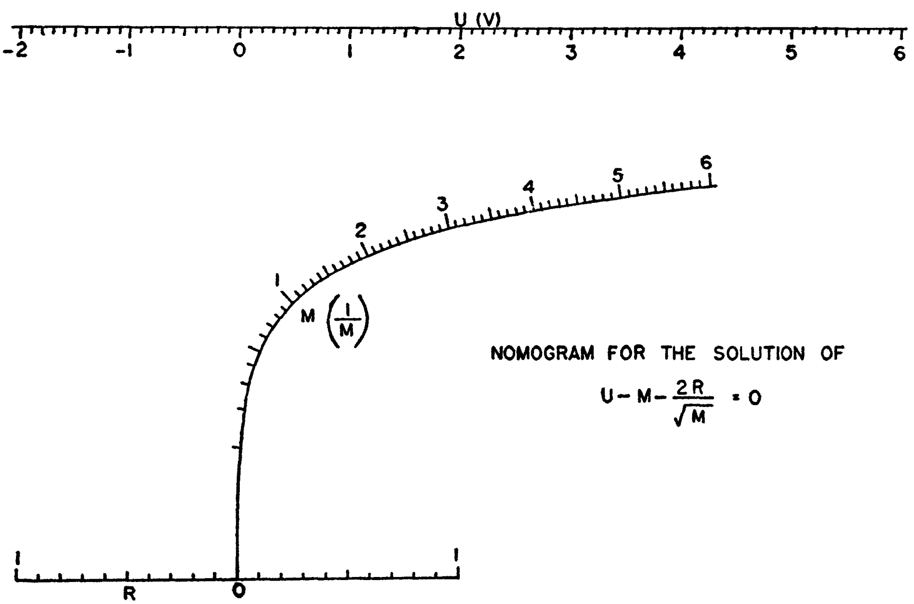


FIG. 4.

out a knowledge of the complex roots, $-P \pm iQ$. To facilitate the calculation of R it is convenient to display Formulas 14 and 15 as nomograms. To do this, we can write (among infinitely many other possibilities)

$$\begin{vmatrix} U & 1 & 1 \\ -2R & 0 & 1 \\ \dfrac{M\sqrt{M}}{\sqrt{M}+1} & \dfrac{\sqrt{M}}{\sqrt{M}+1} & 1 \end{vmatrix} = 0 \quad (16)$$

$$\begin{vmatrix} V & 1 & 1 \\ -2R & 0 & 1 \\ \dfrac{1}{M(1+\sqrt{M})} & \dfrac{1}{1+\sqrt{M}} & 1 \end{vmatrix} = 0. \quad (17)$$

Fig. 4 shows the nomogram representing (16). Two scales are necessary for the variable R because, as pointed out above, the values of R as computed from the roots of (4) and from the roots of (5), while numerically equal, will be of like or unlike sign according as $a_0a_3 > 0$ or $a_0a_3 < 0$. In Fig. 4 the scale of R which extends to the left is to be used if $a_0a_3 > 0$. If $a_0a_3 < 0$ the scale which extends to the right is to be used. Of course if one is solving for R (instead of using R as a datum) one simply reads R from whichever scale the line joining U and M happens to intersect.

We have not drawn the nomogram corresponding to Equation 17 because not only is it superfluous in general, but moreover it is essentially identical with the nomogram of Fig. 4. By comparing Equations 16 and 17, it is clear that the corresponding nomograms are the same except that the U-scale in the former is called the V-scale in the latter, and the scales of M in the two charts are reciprocally graduated. In other words, Fig. 4 can be used as a nomogram for Equation 17 simply by aligning the values of V, on the U-scale, with $\frac{1}{M}$ on the M-scale, and reading R just as before, on the third scale.

It is interesting to note that the value of R determined from Fig. 4 can be used to calculate the complex roots of (5). For from (10) and (13) we have

$$P = \frac{R}{\sqrt{M}} \text{ and } Q = \frac{\sqrt{1-R^2}}{\sqrt{M}}.$$

Hence the complex roots of (5) are simply

$$\frac{-R \pm i\sqrt{1-R^2}}{\sqrt{M}}.$$

The complex roots of (4) can then be found immediately from (6).

Engineering Graphics Fifty Years Hence

J. Norman Arnold, *Purdue University*

Several incidents are responsible for the odd character of this guest editorial. Among them are:

1. The recent finding in an old trunk of a set of student descriptive geometry plates done at M.I.T. in 1873.
2. As a "visiting" staff member with a foot in each of two schools, figuratively speaking, one has a peculiar feeling of unreality and detachment from both; the fact that the two schools are nearly a thousand miles apart intensifies this feeling. These remarks are one manifestation of this anomalous condition.
3. Divergent trends in graphical instruction at present observable in the two schools inevitably induces speculation on the future.

In the space of a page or two it is not possible exhaustively to analyze the past and carefully to hedge some astounding prognostications regarding the future—though it might be fun to do so. However, a brief summary of some generally recognized past history is pertinent.

One of the general trends in engineering education over the past fifty years has been the gradual increase in the proportion of student time devoted to the study of scientific principles and the corresponding decrease in the proportion of time and credit devoted to manual skills, such as drafting and wood-working. In some schools drawings were almost all done in ink 50 years ago; today very few or none are completed in ink. The plates dated 1873, referred to above, were all inked and included rendered problems in shades and shadows. Block-lettered title pages were a part of this set of plates.

Organizational modifications within an institution have a powerful, but slow-acting influence. Fluid mechanics, as taught at present, is more inclusive and general than "hydraulics" and "properties of gases" which it has partially replaced in the curricula. Blacksmithing instruction of the past has become heat-treating and welding of the present, on a more rational and less empirical foundation. Most of the present well-established branches of engineering instruction are an outgrowth of an older one.

In the light of the foregoing, it seems possible that the next fifty years may see the development of a more coherent, inclusive, and general body of graphical principles. At present, there appears to be a group of somewhat distinct graphical or partially graphical courses of instruction, each of which is a mixture of principles, specific applications, conventional practices, and manual skill instruction.

Uniformity in courses of instruction and uniformity in internal organization of engineering schools is neither desirable nor probable. However, a more integrated body of graphical science might lead to reorganization of some schools, associating all graphical science together in one department. Such organization would not mean the elimination of manual skill or artistic instruction. But in view of the trend toward more principles and less practice in the required courses, it probably would mean that the artistic, conventional practice, and manual skill instruction would be primarily on an elective basis for students interested and gifted along this line.

Vociferous opposition from all sides undoubtedly would assail anyone foolhardy enough to offer a program for reorganizing graphical instruction. It is not in keeping with the detached, philosophical, long-range view inherent in the title to suggest such a program. It may be appropriate to offer one hint of ways in which greater generality of instruction seems possible. Vectors, and vector solutions of problems, are a part of several engineering curricula. Perhaps someone may find a way to make vector principles meaningful and applicable for students of all branches of engineering at the same time.

By way of a closing footnote, the Advanced Graphics Committee of the Drawing Division has, as some of its duties, the collection and analysis of graphical methods in use in all scientific fields and the classification and integration into a consistent pattern of the underlying principles involved.

New Members

BLUESTEIN, EARL, Instructor in Architecture, Illinois Institute of Technology, Chicago, Illinois. L. E. Grinter, J. T. Rettaliata.

BOTHWELL, FRANK E., Associate Professor of Electrical Engineering, Northwestern Technological Institute, Evanston, Ill. J. F. Calvert, A. B. Bronwell.

BOURNE, JAMES G., Instructor in Mechanical Engineering, North Carolina State College Raleigh, N. C. W. E. Adams, J. S. Doolittle.

BRINK, JOSEPH A. JR., Instructor in Chemical Engineering, Purdue University, Lafayette, Indiana. R. N. Shreve, T. C. Doody.

BURKE, WILLIAM C., Director of Placement, Lawrence Institute of Technology, Highland Park, Michigan. J. L. Van Vliet, G. P. Brewington.

CRANDALL, LEE W., Associate Professor of Civil Engineering, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. D. Orth.

DINI, ARTHUR E., Instructor in Mechanical Engineering, Bradley University, Peoria, Ill. R. E. Gibbs, C. Linsky.

DOYLE, LARRY L., Graduate Assistant in Civil Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, R. C. Wray.

DUTTON, RICHARD A., Graduate Assistant in Mechanical Engineering, Northwestern Technological Institute, Evanston, Ill. E. F. Obert, A. B. Bronwell.

FITZPATRICK, DONALD B., Instructor in Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. V. Mueller, L. E. Beck.

GILES, WILLIAM T., Instructor in Mechanical Engineering, Bradley University, Peoria, Ill. C. Linsky, R. E. Gibbs.

GOSMAN, ALBERT L., Instructor in Mechanical Engineering, Colorado School of Mines, Golden, Colo. F. R. Campbell, W. Horblit.

GUSTAFSON, LESTER W., Head, Aeronautical Engineering, California State Polytechnic College, San Luis Obispo, Calif. C. E. Knott, F. H. Gertz.

HAAS, GEORGE W., Instructor in Mechanical Drawing, Glenbard Township High School, Glen Ellyn, Ill. W. J. Luzadder, H. P. Ackert.

JAY, DAVID J., Instructor in Chemical Engineering, University of Detroit, Detroit, Mich. G. Duncombe, H. Gudebski.

KOWALCZYK, LEON S., Assistant Professor of Chemical Engineering, University of Detroit, Detroit, Mich. G. Duncombe, H. Gudebski.

KRAUSS, MARTIN L., Instructor in History and Government, Purdue University, Lafayette, Indiana. A. P. McDonald, E. C. Susat.

LARUE, ROBERT D., Teaching Assistant in Civil Engineering, University of Idaho, Moscow, Idaho. J. T. Norgord, H. W. Silha.

LEDBETTER, THOMAS B., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. W. E. Adams, J. S. Doolittle.

MAY, ADOLF D., JR., Research Assistant in Civil Engineering, Purdue University, Lafayette, Ind. K. B. Woods, F. H. Green.

MORRIS, VERA T., Instructor in Mathematics, Purdue University, Lafayette, Ind. A. P. McDonald, A. K. Suter.

NETHKEN, ROBERT, T., Instructor in Electrical Engineering, Lafayette College, Easton, Pa. L. J. Conover, M. King.

NEWLIN, JOHN T., Instructor in Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. W. J. Hollis, E. A. MacLean.

REDD, WILLIAM M., JR., Instructor in Civil Engineering, University of Maryland, College Park, Md. L. E. Otts, D. R. Keller.

RENZ, MERL F., Instructor in English, Purdue University, Lafayette, Indiana. A. A. Potter, H. L. Creek.

REYNOLDS, DON P., Assistant to the Secretary, American Society of Civil Engineers, 33 West 39th Street, New York 18, N. Y. J. M. Garrelts, W. J. Krefeld.

ROBERTS, CLARENCE J., Instructor in Mathematics, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, E. L. Fleckenstein.

ROBINSON, ROBERT F., Instructor in Aeronautical Engineering, Purdue University, Lafayette, Indiana. T. J. Herrick, P. E. Stanley.

ST. CLAIR, CHARLES R., Assistant Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, H. L. Solberg.

SETTERBERG, WILLIAM N., Director and Instructor in Engineering, Junior College of Benton Harbor, Benton Harbor, Mich. W. C. Krathwohl, G. S. Speer.

SMITH, MORTON C., Associate Professor in Metallurgy, Colorado School of Mines, Golden, Colorado. F. R. Campbell, Wm. Horblit.

SPALDING, ALBERT R., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. J. K. Stene, D. S. Clark.

STALLWORTH, TOM W., Professor of Civil Engineering, University of Mississippi, University, Miss. F. H. Kellogg, F. A. Anderson.

STOCKARD, RAYMOND H., Director of Placement, Rhode Island State College, Kingston, R. I. T. S. Crawford, H. E. Graves.

SUNDSTROM, RUDOLPH J., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. R. J. Ungrodt, F. J. Van Zeeland.

SUNG, SING-ZAK, Assistant Master, Engineering Department, Hong Kong Technical College, Wanchai, Hong Kong. A. B. Bronwell, F. J. Sanger.

THIEME, REINHOLD W., Assistant Professor of Civil Engineering, Norwich University, Northfield, Vermont. D. P. Fay, W. D. Emerson.

TOPPETO, ALPHONSE A., Instructor in Electrical Engineering, University of Detroit, Detroit, Mich. G. Duncombe, H. Gudebski.

VAUGHAN, FRANCIS E., Senior Partner, V. & E. Manufacturing Company, Pasadena, Calif. W. J. Luzadder, J. H. Porsch.

WEGENER, MARY A., Associate Director of Placement, Columbia University, New York, N. Y. C. F. Terwilliger, D. A. Roberts.

WILLIFORD, HOWARD K., Assistant Professor of Civil Engineering, Mississippi State College, State College, Miss. H. Flinsch, E. D. Myers.

347 new members this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner, Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Fall, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University U. S. Naval Post Graduate School	Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
* North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 27–28, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
* Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

Candid Comments

Engineers in Public Service

Dear Mr. Bronwell:

For a long time I've had on my desk the October 1950 copy of the JOURNAL OF ENGINEERING EDUCATION. There was one article in that which rather rubbed me the wrong way and I've kept the book before me as I thought I might write to you some time and tell you about it. Morris Llewellyn Cooke presented a paper at the 58th annual meeting of ASEE which you have reprinted on page 68 of the October issue. It is titled "The Role of the Engineer in Community Affairs."

In this article Mr. Cooke takes the engineer to task for his failure to do his part in community affairs. To almost all of Mr. Cooke's statements I find myself in disagreement. I do not believe that the engineer is any worse or perhaps even as bad as are other professional groups in this phase of his life. Mr. Cooke says: "With engineers . . . —citizens status is all but ignored." This is far from the truth as I see it. Later on he refers to: "The failure of the engineer and scientist to participate in community affairs." Also at another place he says that: "Only a negligible percentage interest themselves in public affairs."

Naturally I do not know the situation in the United States as well as I do in Canada but even with my slight knowledge of conditions there it strikes me that a great many engineers take leading parts in public affairs. How about W. L. Batt and Senator Flanders and the various senior officers of the American societies who operate the Engineers Joint Council? All these people have taken or are taking very prominent parts in the affairs of the United States.

In Canada I know of no group that shows as much interest in public affairs as do the engineers. Of course it is the lawyers who lead in politics but once you get away from that showy demonstration of service to the community you will find the engineer occupying more posts than anyone else.

In Canada we have several engineers in the federal house of Parliament and on the federal cabinet there are two—in fact the senior member of the cabinet next to the prime minister is an engineer.

As I travel back and forth across Canada visiting at all our branches I find great numbers of engineers who are or who have been mayors of their communities, aldermen, councillors, school trustees, etc. I see them as heads of voluntary organizations such as the service clubs, the Canadian Club, Royal Automobile Society, and from time to time various cultural organizations.

Right now in Montreal the president of the Montreal Board of Trade is J. B. Stirling, an engineer who incidentally is vice-president-elect of the Institute. He tells me that on the board of his organization there are about six engineers. Also at the last count the executive of the Canadian Chamber of Commerce showed that about ten out of sixteen members were engineers.

Some day I must settle down to preparing a list of interests such as this which are followed by engineers so that I will have something ready to throw at such people as Mr. Cooke just as soon as I find them uttering their adverse comments. I'm sure I can make up a very impressive list of Canadians, and I'm equally confident that an equally impressive list could be made up of Americans.

It's time we stopped this useless and unjustified criticism of ourselves. It is all right to urge the engineers to take even a greater part in public affairs but I don't think that this is where you should start, with an adverse criticism as the basis. Let's brag about what we've been doing and then go on to urge that we do more.

Yours sincerely,

L. AUSTIN WRIGHT,
General Secretary,
Engineering Institute of Canada

Engineering at Michigan State

Annual Meeting—Michigan State College—June 25–29, 1951

By PROFESSORS C. M. CADE *of Civil Engineering* and L. C. PRICE *of Mechanical Engineering*

Michigan Agricultural College, the first of its kind in this hemisphere if not in the world, opened its doors in September 1857 with an enrollment of 40 and a faculty of 7. As might well be expected in a pioneer society, practical applications of basic science were emphasized from its very beginning. Engineering was contemplated during discussions which preceded the formal opening. Some branches of engineering were authorized in the first curriculum, five years before the passage of the Morrill Act of 1862. This act which specifically provided for National support of this and similar institutions included Engineering (Mechanic Arts) as part of the required instruction.

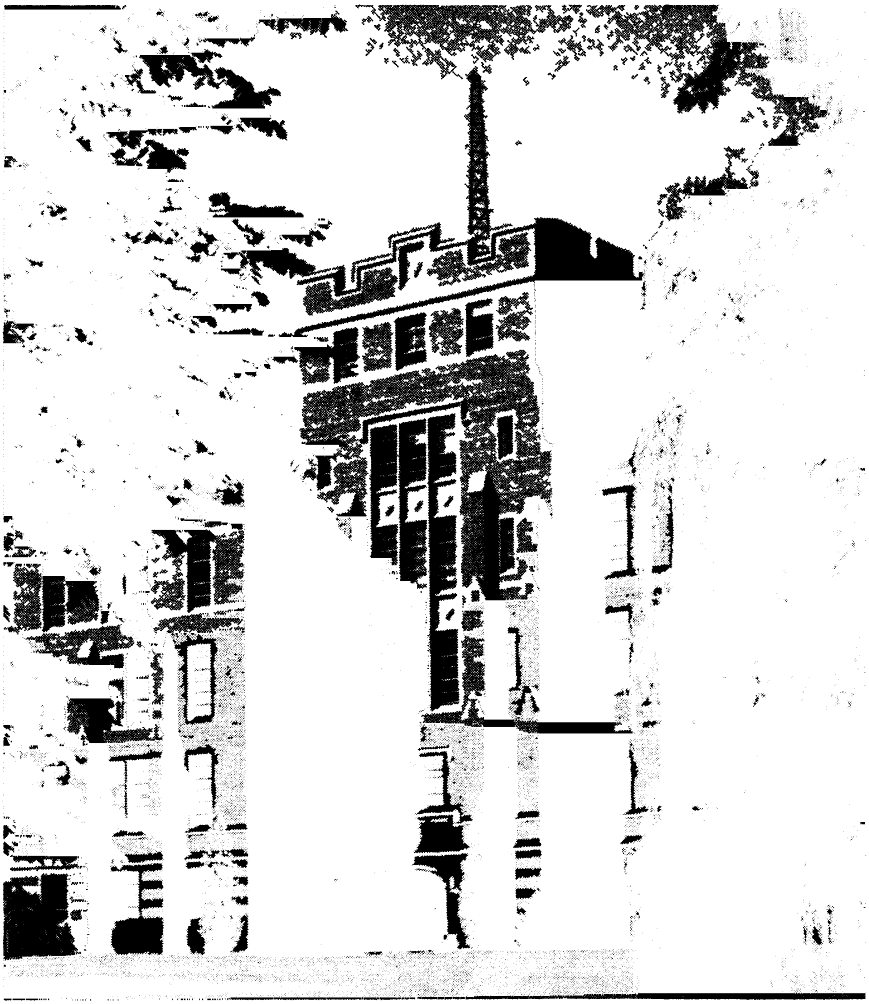
As is often the case, action by some one individual seems necessary to get a new undertaking underway. The individual in this instance was Professor R. C. Carpenter, a graduate of the class of 1873, who, after attending the University of Michigan where he received a degree in Civil Engineering, returned to his Alma Mater to teach Mathematics. Professor Carpenter, after 15 years at M.A.C., went to Cornell University where he was Professor of Experimental Engineering until his death in 1919. Professor Carpenter is well known as one of the leading engineering educators and consulting engineers of the United States.

While at M.A.C. Professor Carpenter prepared plans for the engineering building which served many generations of engineers (1885 to 1907) and continued in service as shops and Strength of Materials laboratories until destroyed by fire in 1916.

With the construction and occupation of this building, Engineering became a recognized part of the work of the college. The avowed purpose of the Board of Control was to establish: "A first class school of technology in which shall be taught the principles upon which the leading industries of the country are based, with a full line of instruction in the use of tools and the construction of mechanical products, according to the best approved plans of such institutions in this country and in Europe. Special facilities will be furnished for instruction and practice in free hand drawing and mechanical draughting, and in experimental physics, with unexcelled advantages in those branches of mathematics and the sciences involved in scientific mechanics. Instruction will also be afforded in the English language, bookkeeping, and the business law, so that each student shall be well fitted by a general and business as well as a technical education for any position he may seek."

This declaration of purpose has served the School of Engineering for well over half a century.

In 1889, the course was officially designated by the name Mechanical Engineering which persisted until 1907 when the title was changed to Engineering Course in which Mechanical Engineering continued as one of the options. In the meantime, Civil Engineering and Electrical Engineering options were intro-



duced—the former in 1901 and the latter in 1906.

The growth of industry during the first years of the twentieth century had a profound effect on the fortunes of the Engineering School. Michigan State College is centrally located with respect to the industrial centers of the State of Michigan, and its graduates are among the leaders in this industrial growth. The earliest effect was seen in the construction of the Main Engineering Building which was first occupied in the Fall of the year 1907. The old building was at that time converted entirely to shops and testing laboratories.

Destruction and Renovation

Fire during the night of March 5, 1916, burned both these buildings to the ground, together with their contents, and including all shops and laboratory equipment. Undaunted by this catastrophe, Administration, Faculty, and students entered into the task of reconstruction. Temporary offices were obtained in the Agri-

cultural Building. Every nook and cranny on the campus was explored for space and equipment. State Departments in the nearby Capital City of Lansing loaned equipment for laboratories. In the meantime, plans were being prepared for a new general engineering building and three shops. The former, built on the foundations of the old building, was named R. E. Olds Hall of Engineering in honor of Ransom E. Olds, the automotive pioneer, who contributed liberally towards the reconstruction.

Growth of the Engineering School required the building of additions to Olds Hall, as well as erection of other buildings. There are now an Engineering Group, consisting of Olds Hall and several other closely adjacent buildings, a Chemical Engineering Laboratory Building, an Electrical Engineering Building, and an Agricultural Engineering Building. Two buildings of the Engineering Group face the Campus Circle, the main drive of the campus. This group was completed in less than a year and was fully occupied just before the outbreak of World War I.

Olds Hall itself now houses the Departments of Civil and Sanitary Engineering, Metallurgical Engineering, and the Research Division of the Michigan State Highway Department, as well as parts of the Departments of Chemical Engineering, Mechanical Engineering, and Engineering Drawing. The Mechanical Engineering Shops and Automotive and Industrial Laboratories are in other buildings of the Engineering Group. Chemical Engineering is housed partly in Olds Hall and partly in a separate building.

Chemical Engineering was introduced during the year 1931 in response to a demand induced by the growth of the chemical manufacturing industry. Offices and laboratories are found on the top (fourth) floor of Olds Hall, while a unit processes laboratory stands just back of the power house.

Agricultural Engineering, a successor to Farm Mechanics, has recently come into its own with the dedication of a new office and laboratory structure among the finest in the Middle West, on May 6, 1948. This building is located south of the original campus across the Cedar River from the main engineering group. It houses the Agricultural Engineering Department, undergraduate and graduate. Unexcelled facilities for research and teaching are found here in the more than 75,000 square feet of floor space thus provided. The course built on the foundation of the old farm shop curriculum is now engineering in the fullest sense. The same basic mathematics, mechanics, and design courses are required as in the mechanical and other engineering courses.

Recent Developments

The latest addition in 1948 to the engineering group is the Electrical Engineering Building containing 68,000 square feet of laboratory and office floor space. This building faces the tree lined Cedar River which flows through the college campus and lands for nearly two miles. It is spanned by several bridges in this distance, carrying traffic to the South Campus, Military and athletic departments, and College Farm of more than 2000 acres.

The South Campus is a recent extensive temporary building development to take care of the great increase in enrollment since World War II. One of these buildings, about 12,000 sq. ft. of floor space, is devoted entirely to engineering offices, classrooms and drawing rooms. Also located in this building will be found surveying equipment for all elementary courses.

The Research Division of the Michigan State Highway Department under the direction of a former professor of the Department of Civil Engineering was established at Michigan State College in 1939. Close association with the Engineering School is maintained. Excellent opportunity is afforded engineering students to participate and observe the work of this section which is located in the

south wing of the main engineering building.

The designation, Agricultural College, being no longer truly representative of the institution, was changed to Michigan State College in 1925. While the institution with enrollment of 16,000 is a university in every sense of the word, it is preferred to retain the designation, College, in order to avoid the otherwise resultant confusion due to the short distance from the University of Michigan.

Michigan State College and its School of Engineering have unlimited space in which to grow and expand. The founding fathers of the last century planned wisely and well and not the least of their planning included ample land area in such form that this facility can not be limited.

ANNUAL MEETING

MICHIGAN STATE COLLEGE

June 25-29, 1951

EAST LANSING, MICHIGAN

Universities and Research for National Defense

By ERIC A. WALKER *

Executive Secretary, Research and Development Board of Department of Defense

The purpose of this article is to explain briefly the research and development program of the Department of Defense and to point out the part that universities can play in our effort to assure that in such emergencies as the present one we will be better prepared than in similar times past.

It is often said that a new war is started with the weapons of the preceding war. Thus, the crude Gatling gun introduced during the Civil War was improved into the deadly machine gun of World War I. In their turn, the crude tanks and airplanes introduced in World War I were developed into the super tanks and aircraft of World War II. During World War II radar, guided missiles, and the atomic bomb made their advent, and it begins to look as if they too will only be improved by World War III, with no startling new developments.

There is a reason for this pattern, one that is quite clear to anyone who stops and thinks about the course of history.

It was decided that World War I had been the war to end all wars and that no further expenditure for war would ever be necessary. Not only did we reduce our Army and Navy and scrap most of our equipment, but we gave negligible support to the military research and development which would give us better weapons if war ever came again. Looking back, it is easy to say that this neglect of research was foolish, for certainly the investment necessary to have kept our weapons ahead of any potential enemy's would have been a small price to pay for the prevention of World War II.

Actually, before World War II the total annual expenditure for research and development by the War and Navy Departments was less than 30 million a year; and, indeed, the total remained near this level even during 1940 when it was evident to everyone that war was imminent. With the coming of World War II, however, vast sums were made available for research and development on new weapons and weapons systems. Very quickly the dollar effort rose to more than 500 million, of which approximately two thirds was spent by the War and Navy Departments and the remainder by the Office of Scientific Research and Development.

It is interesting to note that during World War II the research capacity of the country, measured in dollars, rose from about 300 million to 1¼ billion. This was accomplished by a distinct change in the research administration in this country. No longer was the researcher regarded as a long-whiskered professor working alone in a dark and musty cellar, but he was respected as an unusual person whose talents should be amplified by all the assistance that he could use from secretaries, technicians, and others. At the same time, because of the widespread demand for research workers, many who had the talents and who were not using them were called in from engineering, design, sales, teaching, and other allied pursuits. I mention this only to indicate that although our research capacity increased almost five-fold

* On leave from Pennsylvania State College.

during these five war years, we cannot continue to expand indefinitely, because today almost everyone who has talent in research and development is already working in this field.

For the past five years, from 1945 to 1950, the expenditure of the Department of Defense for research and development has remained at about 500 million dollars annually. The fact that this figure has been sustained indicates an awareness that the improvement of our weapons in years of peace is a good investment.

It is interesting to note, also, that the amount of money spent annually on research and development is today 2½ times the average over-all amount appropriated for both the War and Navy Departments in a year just prior to World War I.

We might mention also that the total research expenditure of the country has increased because more scientists are available—which is good—and because the costs of research have increased—which is bad. Today, in 1951, we believe that the research capacity of the country is about $1,700,000,000. We now hope to increase the fraction of this sum spent by the Department of Defense from 500 million dollars to something in excess of one billion dollars. A question which naturally arises is "Why is this necessary or desirable?"

Experiences of the Past

Let us look back to 1945 and see what our goals were at that time. We had just finished a long war in which new weapons and devices such as radar, the atomic bomb, and the proximity fuze had been developed. During this period, basic research had been neglected, and there were many areas in which our design calculations were on shaky ground, or in which the theory was quite insecure. It was obvious that these gaps had to be filled and that basic research had to be extended to provide a foundation for further developments and newer weapons. Moreover, much of our new equipment was cumbersome and, to some extent, unreliable. It was increasingly desirable to simplify and improve our equipment and many contracts were written with this in mind. Many new research projects were undertaken, and a goal was set for the termination of these research programs in 1955 or 1960. At the end of World War II, it seemed safe to assume that we had fifteen years of peace ahead of us. Now we know that this was not true and that if there was formerly an expectation of war by 1960, we should now be ready at a much earlier date—1955 or perhaps even 1952.

The nation, through Congress, has decided to assume a new and different military posture. We are to increase our number of air groups, strengthen and enlarge our Army, and add to the ships and carriers in the Navy. This means we must buy new weapons, but what shall we buy? Are we once more to buy replicas of the weapons of the last war, or should we have new weapons which can again put us one step ahead of our potential enemies?

Obviously, we should like to order only newer and better weapons, but where the development of these has not been completed, the blueprints are not ready, and the best we can do is compromise—buy some of the old weapons now and rush through our development program so that within the next year or so we can be prepared to build and issue to our forces the best weapons available.

The solution to the problem of military research and development is not an easy one, and many dislocations can be seen as we move from old schedules into the new ones. There is no over-all solution to the problem. Each item must be treated specially and the best solution found. We are finding these solutions and will continue to do so.

What can the universities do to help in this situation? The answer is almost obvious. The universities played an important part in the research and development program of the Office of Scientific Research and Development during World

War II. Many of them held important contracts with that agency, and they also contributed importantly to the staffing and administration of the Office of Scientific Research and Development by the loan of such eminent educators as James B. Conant, Karl T. Compton, Edward L. Moreland, Roger Adams, and many others.

Agencies of Research Administration

The creation of a special agency to spearhead military research and development will probably not be repeated. There is not the huge gap in the program that existed in 1940. There is a much keener appreciation at the higher levels of our armed services of the value of research, and funds for research and development have not been seriously curtailed. Mutual respect between the scientist and the military man has grown since the wartime experience. For these and many other reasons, it seems doubtful if a new, independent, free-wheeling organization will be established. Indeed if it should be, it would be difficult to escape the impression that the armed services themselves had failed.

During the past five years the universities have taken a considerable share of the research and development dollar and have assisted mightily in the task of improving our weapons as well as restoring our supply of fundamental knowledge. In cold figures, the universities have undertaken about 9 per cent of the total program. If the military research and development program is to be increased, there are reasons why the university share should be increased in the same proportion. In all probability this can be done, to the mutual benefit of the Department of Defense and the universities themselves.

Some startling figures have been published, indicating the tremendous drop in enrollments in succeeding engineering classes. These figures need not be repeated here. However, the very fact that there will be fewer students means that fewer professors will be needed for instructional purposes, and unless colleges are better off financially than I think they are, there will be many college professors looking for new jobs. Unfortunately, in times like these it is the better man who finds it easier to move, and because there is such a huge demand for research people the universities are likely to lose many of their good research men, unless adequate opportunities can be proved on the home campus.

These opportunities do exist, and more can be created. Already there are universities which have contracts with the Department of Defense, either through the Office of Naval Research or the Bureaus of the Navy or the various commands of the Army and Air Force. The armed services wish to use more university people, but unfortunately not as many in the area of basic research as the universities might desire.

The Department of Defense has a firm policy on basic research which provides that the support of such research in any given year shall not fall below a level of 6 per cent of the average sum spent on research and development during the preceding five years. The support of basic research, however, is not the chief purpose of the present research and development effort.

The purpose of this effort is to get weapons into the hands of the fleet and the land and air forces. We want to buy time with money. We want to build two prototypes where before we could afford only one, and we want the blueprints and specifications quickly. So, if the universities are to assist, they must be prepared to assist in development as well as research programs. Development is the activity in which the engineering schools can be of particular assistance.

Industrial Fellowships for Graduate Study from the University Viewpoint*

By W. L. EVERITT

Dean, School of Engineering, University of Illinois

It has been said that "The greatest study of man is man himself." The study of man cannot be separated from the study of his environment, because unlike other animals, the environment of man is determined largely by his own activities. One of the most productive and stimulating of man's activities is the field of research. The productivity of this research is determined primarily by the men who engage in it and the environment with which they are surrounded.

Astounding to the historian are the rapid changes which have been produced by the industrial revolution in a period which is infinitesimal compared with the life of the species. It should be recognized that the products resulting from technology have produced more profound changes in our social structure than any of the actions of the social scientists themselves. The sociologist and the economist may observe and codify the interaction of social forces but the research and invention of the engineer and scientist have been the source from which the majority of these forces have arisen. In this group I do not need to speak in praise of research because we accept its importance. We are here rather to discuss a particular method of supporting research. Although the increase in the number of industrial workers since the turn of the century has been enormous, the increase in the percentage engaged in research has been much greater. Even greater than this has been the increase in the number of words written and spoken in groups discussing research.

The development of modern methods of communication, particularly the scientific and engineering journals, have removed the conditions faced by primitive men when the same experiments were repeated by different individuals because the one did not know what the other was doing. Repetitive experiments are useful in teaching but they are not research.

Competitive and Cooperative Research

Some research has been and must necessarily be restricted in the distribution of its benefits, because it is intended to give one group, either industrial or national, a competitive advantage, but I feel that this type of research has no place in the university and we are discussing today a cooperative problem rather than a competitive one. This principle of cooperation can guide us in the type of research program which should be supported at the university by outside assistance. Webster defines a University as "an institution organized for teaching and study in the higher branches of learning." Here the word "study" is synonymous with research. An educational institution that does not support research is not a University. This is generally admitted. What is not so generally agreed is that the expenditure of effort on the part of the staff and the financial support for research ought to be comparable with that for teaching. As a result Universities have found it

* Presented at a meeting of the Graduate Division at the Annual Meeting of the ASEE, Seattle, Washington, June 23, 1950.

necessary to depend to a large extent upon outside support in order to maintain an adequate research program. Much of this support has come in the form of industrial fellowships or in fellowships associated with research projects under government sponsorship.

Purpose of University Research

The purpose of University research is three-fold:

(1) to advance fundamental knowledge.
(2) to train research workers.
(3) to vitalize both graduate and undergraduate teaching.

We also recognize that there are four types of research organizations:

(1) industrial.
(2) government.
(3) independent research institutes.
(4) universities.

If we are to be cooperative rather than competitive I feel each group should recognize its own purpose and responsibilities. There are certain types of research which can best be done in the University and other types which can best be done in other types of organizations. The University should not try to set up a replica of the industrial laboratory, nor should its projects be merely the overflow which industry does not have the time or interest for itself. Certainly, in the field of education, the University recognizes that there are certain principles and methods of thought which it can teach best and there are other areas of knowledge which the individual can learn best on the job, and it guides its program accordingly.

We should recognize that there is also a certain difference between science and engineering and within the University this must be kept in mind. I have suggested in other papers that the difference between Science and Engineering is the difference between Analysis and Synthesis. The scientist will want to know what will happen if a certain physical combination exists. Engineers want to know what combination should be assembled to make a desired result happen. This has led in the past to the feeling that the pure science departments in the University, such as Physics and Chemistry, should do the fundamental research on the nature of the physical world, while the engineering departments should confine their attention to the application of these principles to practical devices. I believe this concept has had a most sterilizing influence on Engineering education. Under its influence, basic research in many institutions (perhaps most) *was* left to the science departments but *applied* research, because it could be done better in many ways in industry, moved out into the commercial laboratories. Thereupon the engineering departments settled down to teach but not create, and research in the engineering schools declined to a low ebb. Unfortunately such a condition is degenerative, because if little research is done, the ability to do it atrophies, and the limited funds available for research in the universities are diverted to other fields. This also causes, in turn, the value of advanced degrees in engineering to depreciate, and the industrial and government laboratories themselves recruit their research workers for the applied or engineering fields from the science departments. During the war, when daring and ingenious applied research was needed for war developments, the available sources for personnel of sufficient training were limited and lay in the fields of pure science.

The opportunity for the development of a strong and virile research program in the engineering departments therefore lies in basic research. Because the frontier of science is so broad, we engineers should be advancing on a multipronged frontier and not crawling up behind the spearhead being pushed by the physicists and chemists. By its very nature, physics throws most of its energy and personnel into an attack in a limited number of directions at a given time. At present the emphasis is on nuclear physics,

Sometime ago it was on spectroscopy and quantum mechanics. Actual research programs should be determined by fields of interest, and the contribution which a given background can make to new problems. Because of his knowledge of, and driving interest in, circuits and electronics, the electrical engineer should be best equipped to study such areas as acoustics and vibrations of all kinds, electron and ion dynamics, electromagnetic field problems, measurements in general, digital and analog computers and so forth. In turn the mechanical engineer is interested in heat flow and energy conversion; the aeronautical and hydraulics engineer in fluid mechanics and the metallurgical engineer in the physics of the solid state. These provide a host of fundamental problems which the engineer can and must solve, for the physicist and chemist are engaged elsewhere. I feel strongly that this is the opportunity and mission of University research, whether supported by internal or external funds.

Sponsored Research and Faculty Interests

In general, research projects should be originated by the staff who are to do the work. This is particularly true of basic research. Self generation is sometimes difficult in the early stages of building up a research program, but should be developed as the staff matures. Research begets research and a staff which does not generate more projects than it can handle should be looked on with suspicion. We feel, therefore, at the University of Illinois that programs sponsored by industrial and government sources should be built around the interests and competence of those leaders on the faculty who will direct the program. However, in order to be the cooperative venture it shoul be, this indicates our faculty in turn should be kept constantly aware of the state of the art and the needs of industry and government. On the one hand we do not feel it desirable to bring in industrial contracts just because an outside organization has something they need done, and on the other hand we recognize that only if industry and government are interested can we secure adequate support. We hope, therefore, by discussions such as this and by other means of liaison we will get to know our mutual problems better and can continue to work out programs of common interest. In the selection of projects negotiations with sponsors are sometimes difficult, but sponsors will recognize that they will get the best results if there is a real enthusiasm and competence on the part of the worker in the area to be investigated.

In a University research program, projects should also produce theses for graduate students. Worthwhile programs are so expensive that it is generally necessary for the students to integrate their theses problems into the general research program adopted for the department.

One of the greatest opportunities of University research is the development of programs involving cooperation between two or more departments and outside organizations. The University has an advantage over almost all industrial laboratories in having on its campus experts in many fields. Engineering involves both men and materials, and the psychologists, the physiologists, medical men and others can give cooperation unobtainable in industry. The interchange of ideas among departments and in turn with industry fertilizes the minds of all the groups participating and I recommend more and more of this type of activity.

It is axiomatic that routine testing and pot-boiling projects should not have a part in the basic research program of any university, although they may be necessary in special cases to win friends and influence people.

Most important of all in a research program is the selection and development of the personnel involved. Naturally they must have a creative imagination. But contrary to popular opinion, the research worker in the University should also like people. He must be able to work with

his associates, particularly students. The full-time or permanent staff should be stimulating to graduate students and able to develop in them both the spirit and method of research. In the university the production of virile research workers is more important than the research itself, but it cannot be done by routine teaching methods. It must be done by actual research programs.

It is generally recognized that the future of industry depends greatly upon good fundamental research. Even more, the strength of our nation depends upon this. In the past, universities have received much of their support from the contributions of individual benefactors. This source has largely disappeared. The support of undergraduate teaching may be continued on the basis of existing endowments and on state revenue but the training of research workers will depend largely upon the support through industrial fellowships and research programs supported by industry and government. The increased interest in graduate work has resulted in a large increase in enrollment of graduate students in the Engineering field. At the same time the cost of doing worthwhile research has increased astronomically. I feel, therefore, it is the duty of industry, and, in fact, to their own interest, to increase the support of industrial fellowships not only by increasing their number but also by increasing the auxiliary support necessary to supply research workers with equipment and shop help. This is largely done through the medium of cooperative research programs which are a large part of our program of industrial fellowships.

I feel, moreover, that industry should speak up in its support of research and its necessary companion, graduate work. We have had, in the past, a situation where many organizations who advertise their own research programs, simultaneously send out personnel recruiting agents who advise the most competent graduating seniors to come directly with their company and not to continue their graduate work. At the same time an examination of the technical publications produced by the staff of these same companies, shows that the men who are producing the really new ideas, have been recruited from those with advanced degrees. This inconsistency has been a real problem to face in many Engineering colleges.

Sources of Industrial Fellowships

Most support of industrial fellowships at universities has come from a relatively small number of large organizations. It seems desirable to develop more cooperation with small organizations. In the past, where such cooperation has been developed, it has been largely through the medium of trade associations who collectively can recognize basic research programs which the individual company cannot support alone. This type of operation has been so successful in a few cases that it is hoped it will extend to others.

Cooperative programs of research have another stimulating effect on an industry or section thereof. The most progressive students tend to look around the universities and judge for themselves what the most active fields are. True, this may be an inadequate picture, but it happens nevertheless. In turn they are apt to choose such an area of activity for their own work and seek employment there when they graduate. Those areas which are not represented in University research tend to be avoided by the best students when they graduate; even by those who leave at the end of the bachelor's degree. Therefore, it is to the self interest of those sections of industry which can benefit from good engineering graduates to see that their field is represented in the research activities on the campus.

One problem which used to give some difficulty, but which I believe is now disappearing, is the right of the university research worker supported by industry to publish his results. One who hides his light under a bushel gives no illumination, and the man who does not publish has not completed his research. There may be some justification for withholding the results of research in the case of in-

dustrial companies or where military problems are involved, but this should have little place in the university in times of peace, and I feel that restrictions by industrial sponsors should never be made.

The relatively large research programs now being conducted in the universities are supported largely from government sources. Support from a limited number of sources is always dangerous to the university because of the reductions necessary if such support is withdrawn. This in turn may place undue pressure upon an individual department, or university, to accept undesirable programs in order to avoid and maintain continuous operations. We hope, therefore, that more and more support will come from industrial sources commensurate with the distribution of the total economy.

Upon the success of the university research program the ultimate success of industrial and government research will be founded because we must supply the personnel. We are not competitors, but co-workers. We must work together as a team in one of the most important of all human endeavors.

Summer School
Humanistic Social Division
June 21-23, 1951

The Humanistic-Social Division of the ASEE is now making plans for its summer school to be held at Michigan State College in June immediately preceding the regular meetings of the Society. The summer school will be held June 21, 22, and 23rd, and the Divisional meetings of the regular session will be on June 25 and 26. Anyone interested, therefore, can attend both the summer session and the regular Division meetings in a period of six days.

The past two summer schools have been devoted to consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering. All of those who have attended have felt that this interchange of ideas and discussion of common problems has been well worth while, and it is hoped that this year's session will be as valuable as the past two have been.

All members of the Society are cordially invited to attend any or all of the summer school sessions and to participate in the discussions. Anyone who is interested in attending or who has a problem he would like to present is urged to write to Dr. John W. Shirley, North Carolina State College, Raleigh, North Carolina.

General Industrial Practice Regarding Fellowships*

By MARTIN J. BERGEN

Chief Draftsman, E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware

Foreword

This paper is an attempt to give the facts with regard to Fellowships, as they pertain to present general industrial practice. Therefore, the paper does not represent the practice or thinking of any one company.

It is not recommended that present Fellowship practices, which are in use between companies and universities, should be changed, because it will be found, upon examination, that such companies which have been progressive enough to institute Fellowships are providing the major support to the Fellowship program.

Should the facts which are contained in this report be applied primarily to the development of new Fellowships with companies which do not have such university affiliations now, the income derived from such increased use of Fellowships might readily run to ten or more times the present income derived from Fellowships.

Present Industrial Practice

In this paper on Industrial Fellowships for graduate studies, it is my job to present the industrial practice at the present time. It can be stated with a fair degree of accuracy, after studying the situation, that there is no coherent and unified industrial viewpoint that can be presented. However, certain facts which may be of interest can be presented, and probable trends can be examined, which may lead to an eventual crystallization of an industrial viewpoint which can be co-ordinated with the viewpoints of the universities and government.

It is only fair to state that there seems to be a definite underlying trend toward fundamental research in the universities under Fellowships granted by Industry without any, or with very few, restrictions being placed upon either the university or the Fellow in choice of field. In addition, this trend indicates that such fundamental research should be published and be added to the body of knowledge available to all.

Course Pursued in This Study

An examination of the literature in this field showed that the written material concerning Fellowships was in the shape of articles in the Engineering magazines and reports from the National Industrial Conference Board, National Research Council, and other sources interested in research. This material was studied extensively. In addition, quite a few letters were written to responsible men in various companies in order that amplification of this published material, from specific company points of view, might serve as a better background for this report.

Historical and Comparative Background

Let us briefly look at the background underlying the Industrial Fellowship system. We find that the Fellowship system is less than 45 years old. It

* Presented before the Division of Graduate Studies at the Annual Meeting of the ASEE, Seattle, Washington, June 23, 1950.

was started with a very modest grant of $500.00 in the chemistry department of the University of Kansas in 1907. Since that time it has grown, so that the order of magnitude of the dollar value of the industrial Fellowship system is around, or slightly better than, two million dollars a year at the present time. Let us examine the relationship between this present expenditure for Fellowships and the expenditures in some other fields with which Fellowships might be compared.

In order to do this, we will have to examine the several phases of industrial research. Examination shows that, on a national scale, industrial research is a huge business undertaking, involving the expenditure of more than a billion dollars a year. Looked at from another point of view, industrial research employs approximately 200,000 people in the United States.

There are two divisions of industrial research that should be examined more in detail.

One division is composed of the research performed by the tax-paying commercial consulting research organizations. There are approximately 300 such organizations in the United States, many of them with specialized facilities in particular fields of technical research. On an order of magnitude basis, these research companies are doing approximately 40 million dollars worth of business a year and are employing approximately 4000 people.

The other division comprises the research performed by the non-profit research institutes, such as Battelle Memorial Institute and Mellon Institute. We find these institutions are doing approximately the same amount of business as the commercial research organizations.

In addition, we have the research done in the colleges and universities under Fellowships and industrial grants. Data obtained for 65 reporting colleges and universities, for the period at the end of the war, showed that the total of the industrial grants for research for these 65 schools was 25 million dollars. Of this amount, Fellowships represented only two per cent or approximately ½ million dollars. By expanding these figures statistically, it is estimated that the probable total received by grants for research in all forms by the colleges and universities was between 75 and 100 million dollars. Of this sum only two million dollars was allocated for Fellowships.

Significance of the Use of Fellowships

From the above data, it is apparent that, in the use of Fellowships, we have an activity for which, it is estimated, only two million dollars a year of industrial money are spent, as compared with the total industrial research activity of the United States, in which well over a billion dollars a year are spent. Since this is the situation, one might readily ask, "why should there be any great amount of significance placed on the Fellowship situation from the industrial viewpoint?"

Now, the Fellowship situation is important for these reasons:

1. Industry has realized for a long time that the supply of competently trained research men, who are receiving research training in formal fashion from the colleges and universities via graduate work, has been insufficient to man the growing industrial research organizations. This demand is mainly satisfied, at present, by Doctors, Masters, and Bachelors who are graduating in increasing numbers. Many of these men would like to get further training in research.

2. There has been a growing appreciation in industry that industry has a responsibility to assist in the additional research training of such men, by providing funds to enable such training to go on. However, it can be seen that the training under Fellowships alone would never begin to satisfy even a replacement demand that industrial research organizations have at the present time.

3. An examination of the wide diversity of the use of Fellowship plans by different companies and in different universities, shows pretty conclusively that indi-

vidual industries define the mechanism of the Fellowship differently. This change of definition from industry to industry changes the meaning of the Fellowship, in each case, as it pertains to:

(a) Industry
(b) The University, or
(c) The holder of the Fellowship.

4. Partly, because of this fact, the Fellowship field has had very little industrial use. This applies with special emphasis to medium-sized and small businesses, which neither seek the use of the facilities nor the aid and counsel of the faculties of the various schools and universities to the extent that they should.

5. We find small businesses using Fellowships less extensively than big businesses. If this condition is corrected in the future, it is believed that the rate of growth of Fellowships can be vastly increased.

6. As a result of this probable increase, the Fellowship system may become an important adjunct in assisting the universities to obtain the industrial support they need so badly, in order to continue as free institutions.

Fellowships Defined
Preliminary

I have been talking about Fellowships without defining what they really are. In order to clarify the situation, let us see if we can determine what a Fellowship was at its inception, and what it still is.

As we explore the situation, we will find many degrees of difference from the general definition. Some comments will be made about these differences, because they point up differences in industrial thought.

Definition

A Fellowship is a specific grant to an individual or group by a donor industry, or group of industries, carrying with it certain contractual responsibilities and tangible benefits to:

1. The industry or industries.
2. The recipient or holder of the Fellowship.
3. The scientific or educational institution at which the Fellow will perform his work.

Most of the differences in various companies seemed to surround these contractual responsibilities. We find some industries exercising no control of, and receiving only indirect and long-range benefits from, their Fellowships, because they deem it best to allow the university to pick the Fellow, the field of research, and the problem. These industries share only indirectly, and on a long term basis, in the fruits of the research. Such an attitude is a splendid one to foster fundamental research.

Some corporations, however, use the Fellowship mechanism in a different fashion, modifying the contractual basis until the other extreme, detailed below, is reached.

At this extreme we find companies using the Fellowship mechanism in one or a combination of the following ways:

A. The company and the university consider that the Fellowship is a contract and that the university shall be responsible for the work done under the contract, to assist in the solution of such research problems as the company has need to be solved.
B. The company provides the necessary stipend to the Fellow and, in addition, usually provides for certain other expenses, such as the cost of laboratory or other materials.
C. Payments are also made to the university for the use of its facilities in connection with the working out of the research problems.
D. Under the terms of the contract, the industry may have the right to designate:
   (a) Whether or not the results shall be kept secret or divulged.
   (b) Who owns any patentable rights that are the outcome of the research.

(c) What disposition shall be made of the research results.

E. In addition, some industries write further restrictions into the contract, such as:
   (a) The selection of the Fellow.
   (b) The Fellow's responsibility toward the donor company after the terms of the Fellowship have expired.

F. In some cases, some companies require or expect a Fellow to become one of their employees for a stated length of time.

Discussion of the Different Points of View

Now there is a vast difference between these two extremes of operation concerning Fellowships, and with such a range of choice, divergence of opinion grows automatically as time goes on. As a result, we find Fellowships incorporating all possible combinations from one extreme to the other. Any industry has a perfect right to grant Fellowships on the basis that seems soundest to it, but this basis should be one which will foster the growth of fundamental research, and be instrumental in expanding the Fellowship mechanism to the degree needed by the universities.

Should the other extreme, described in detail in A. to F. above, be considered by companies, which are not now using the Fellowship plan, as a valid industrial tool to expand their facilities, these companies should investigate the services of the Research Institutes, either those controlled by the universities, the independent non-profit institutions, or those which are operating on a commercial basis.

Assistance to Medium and Small Industries by Use of Industrial Fellowship in the Research Institutes

There are a number of companies which today are very successfully using Fellowship programs. These companies, and the universities which are working with them, have defined in what part of the range their particular definition of a Fellowship would and should lie. Nothing in this report should be construed as an attempt to change these successful and growing operations, because these companies and these universities (in each specific instance) have a pretty good understanding of their objectives.

Companies (especially medium and small-sized companies) which are invited to embark on Fellowship programs can be assisted by the work of a joint committee from industry, the universities, the Research Institutes, both commercial and university sponsored, and government. This committee would acquaint industry in general with the general scope of Academic Fellowship requirements for fundamental research.

In addition, the requirements, responsibilities, and rewards connected with Industrial Research performed in:

(a) University Research Institutes,
(b) Endowed Research Institutes,
(c) Taxpaying Research Companies, and
(d) Government Research Organizations,

can also be detailed by this committee.

If this information is disseminated widely, many of the medium-sized and smaller industries will discover that they can use these Industrial Research facilities to a much greater degree than they are now using them.

For example, an industry using a Research Institute would acquire the facts pertaining to the method that the Research Institute would use in connection with the research problem, which the industry has to solve. The industry, in turn, would acquire information as to how the problem would be worked on, who owned the property rights involved in the fruits of research, and all other pertinent facts concerning this research.

With companies becoming research-minded by use of Research Institute facilities, the problem of getting them in-

terested in fundamental research in the universities, on the right kind of a basis, should be easier to solve than it is at present.

In quite a few cases, industries which are members of various Trade Associations might profitably use the Fellowship vehicle through the Trade Association. An example of one of these organizations is the Foundary Educational Foundation.

Points for Further Study

We find, at the present rate of growth, that industrial Fellowships will probably increase in magnitude to approximately 20 million dollars a year by 1960. It is evident that this rate of growth is insufficient for present and future requirements, and that it must be increased in order that the Fellowship program become an effective financial component, contributing to the support of the universities.

Therefore, the following points might be studied by the universities and industries which are contemplating Fellowship plans:

1. *Universities should prosecute fundamental research in science and engineering, in fields that they are now equipped for,* and should acquaint medium-sized and small industries, not only in their own localities, but over a wider region, with their facilities for such fundamental research.

2. These universities should obtain the necessary literature from the various research foundations, and commercial research organizations, describing Industrial Research in simple language. This literature should be placed in the hands of industries in the region of influence of the university. This will enable medium-sized and small industries to realize that they (the industries) can take advantage of the facilities the Foundations and Commercial Research organizations have to offer. This, in turn, will make industry in the region research-minded, and should make them open-minded to becoming contributors to the universities for fundamental research, thereby assisting in the growth of such research.

3. The officers of the universities should realize that there are many discoveries that will profit mankind and lead to further basic knowledge, by doing fundamental research, on an unrestricted basis, for smaller industries. Also, the universities will assist the smaller industries of the communities of which the universities are an integral part.

4. As a result of the above, and with an eventual increase in the number of Fellowships for fundamental research, more young men should be trained in the principles of research, so that the huge industrial research plant, mentioned earlier, may be effectively manned, and may continue to grow.

Civil Engineering Conference

The Civil Engineering Division of the ASEE will hold a conference of civil engineering teachers at Michigan State College, June 23–25, 1951, immediately preceding the Annual Meeting. The program and local arrangements are being made by Professor C. O. Harris of that institution. The program will include sessions on "Teaching as a Career"; "Teaching Techniques"; "The Value of Electives in a Civil Engineering Curriculum"; "Written Materials for Teaching."

Method is the Bond *

By ALLEN GILMORE

Chairman of Department of History, Carnegie Institute of Technology

In this uncertain world of ours there is one conviction to which we all hold firmly: that there is a right way of going about a job. Whether you are an English scholar or a chemist, an historian, mathematician, or electrical engineer your craft has established, more or less clearly, and practices a technique or set of skills, a *method* about which there is no fundamental difference of opinion. A good professional performance is recognizable as an example of method in action: it is orderly, it is controlled, it has a quality of rigor and demonstrability. Furthermore, and on this everything depends, the essential characteristics of good performance in one field have much in common with the characteristics of good performance in all fields. Method is the bond that unites the separate areas of human thought, interest, and action. Good method in mechanics is like good method in anthropology, economics, or chemistry. On the basis of this element common to all disciplines, integration in education may be planned and achieved.

The case may be put more strongly: on this common element, because it is the only point of real community, integration must be based. There is no final agreement to be had in our day about the content of knowledge. As to conclusions, not only in the fields of the humanistic and social studies but also more and more in the sciences, conviction is strong but diversity prevails. One man's meat is another man's poison. We may not agree with the empiricists and pragmatists who tell us this is as it must or should be, but, if pressed, we must all confess that this in fact is how it is. The search for certainty and final answers has given way almost everywhere to a more humble and tentative effort to discover an answer that is relatively true, that is, all things considered, the best or the most workable or the most useful in a particular set of circumstances. But while right answers may no longer be said to exist, right ways of thinking do; and an education designed to lead students to recognize and to practice right ways of thinking in all their work will go a long way toward being an integrated education.

Dr. Jekyll and Mr. Hyde

The fact that students do not perceive this bond of method between the various fields they study explains a good deal of the disintegration in their education. Engineering and science students (to take a striking example) tend wrongly to regard humanistic and social studies as fields in which disciplined mental processes do not exist. In physics or mechanics they recognize, even when they are unable to practice, controlled techniques of analysis and rigorous methods of thinking. In history or economics or English, they are likely to say, it is all a matter of opinion anyway, and one man's opinion is as good as another's. They make up their minds in these fields on the basis of hearsay, wishful thinking, authority, prejudice, or the latest story circulating at the corner drugstore. In effect they split the unity of experience

* Presented at the Summer School of the Humanistic-Social Division of the ASEE, Seattle, Washington, June 24, 1950.

into two worlds which have little in common: one, the world of nature, is orderly; the other, the world of man and society, confused; one has discipline and method, the other has not. In this they reflect a deeper disintegration which unfortunately seems to be one of the main characteristics of our culture. Dr. Jekyll builds bridges, discovers miracle drugs, and explores nuclear energy with precision and with striking success, while Mr. Hyde rows with his wife, goes out on strike, and drops atomic bombs. And in doing these things Mr. Hyde is characteristically confused and unhappy, his action fumbling and disordered.

In part this schizophrenia is a result of exaggerating the achievements of science and technology while underestimating those of the humanistic and social studies. In part it is a consequence of misunderstanding the nature of accomplishment in both areas. For science has not found and no longer expects to find a set of right answers, as students and the public too often think. Science is rather a way of doing things, a way of behaving. And in history (to take an example from the so-called non-scientific area) the same is the case. An historian is not someone who accepts a particular set of propositions about the past; rather he is someone who acts like an historian, who applies in a particular area of human experience certain methods and techniques. His answers may not be final, and certainly are not simple or expressable in neat mathematical terms, but the procedures by which the answers are reached are (if he is a good historian) as disciplined, as rigorous, and as controlled as those of a physicist.

If one attempts to name the baby, to state explicitly in terms as fundamental and simple as possible what these procedures are, the unity of all good thinking becomes apparent. In emphases, in particular skills refined in one field or another for special purposes, the differences are many and they are important; but in the main good method in one profession involves the same mental processes, going in an orderly way through the same steps of analysis, taking the same precautions, as good method in all others. Alfred North Whitehead has said that the great invention of the 19th century was the method of inventing. Engineers and scientists refer to the same thing when they speak of a method of problem solving. One statement of the essential elements involved in such a method begins by insisting on the identification and definition of the problem to be solved. Other elements are the formulating of a plan of solution, the execution of the plan and, finally, the checking of the whole, learning and, if possible, generalizing from the process.

Implementation—an Example

In order to make clear how I believe an integration based on method is possible between the humanistic and social disciplines on the one hand and the scientific and technical on the other I would like briefly to describe a freshman history course planned with these ideas in mind. The course is required of all freshmen at Carnegie Institute of Technology, meets in small sections three times a week through two semesters, and is the introductory element in a four-year social relations program. What is peculiar about history (at least for the purposes of the program under consideration) is that it deals with human experience as a totality and takes account of the past. This being so, the objective of this freshman course is to develop in the student the ability, the habit, and the desire of thinking and acting in this broad area in a critical and controlled way.

It is necessary that history teachers in engineering and science colleges face squarely the fact that their students will always be amateurs in history. In other institutions it is possible (I am afraid it is even usual), for history courses to be taught on the assumption that the good student is going to grow up to be a professional historian, a replica of his teacher. As a consequence, what is useful is taken as what is useful to the prac-

ticing historian, which too frequently turns out to be the gathering of a quantity of information about the past. Clearly, such information is not in itself of value to the engineer or scientist.

The content of the freshman history courses at C.I.T. is therefore limited by conscious decision. Knowledge about the past is considered a means to the attainment of the main objective, and not an end in itself. The great principle is: there is nothing that can't be left out. It follows that what is included as subject matter is there for a purpose: because it is fundamental to later learning in the course or in other courses, or in afterlife. The course deals with the development of western civilization, but it is not a survey, and the effort is to leave out rather than to put in (or "cover") as much as possible. The major criteria for selection or rejection are two: First, that it be possible for the student to put together *a* coherent account of the growth of our culture with a sense of the long-term flow and connectiveness of the past; and second, that, where possible, material be chosen to develop a general breadth of cultural awareness. Any particular event of the Italian Renaissance that you wish to name may be omitted, but the student should know what the term has come to mean, and he should be able to place the period in the course of western history as a whole.

In order to design a course that aims to teach good thinking it is necessary to consider the point of departure. Our freshmen are not, I imagine, very different from freshmen anywhere. Their thinking habits in areas related to the activities of human beings in society are atrocious. They make snap judgments that are rashly oversimplified on the "either . . . or" principle: *all* good or all bad, all right or all wrong. They make use of elaborate metaphors (like the "cold war" or "the birth of the United States") with little or no concern for the literal reality. They are easily moved by emotion and by strong but often unperceived bias. They accept too readily a simple authoritative assertion, especially if it be in print. To them the world of human and social action is flat and two dimensional, like the world of a comic strip; a situation is simply there and the possibility of analyzing it, of seeing it in depth as a part of an understandable process, does not occur to them. Furthermore, they are content with this. In their minds analytical thinking and disciplined methods simply do not exist in this area—in the world of nature, yes; in the world of man and society, no.

This being the case, it was necessary for the staff of the course in question to decide what were in fact the essentials of good method in this area. In order to do this the instructors endeavored to describe their own mental operations when as good historians they were dealing with a problem. The objective of the course it was decided on the basis of this statement was to train the student to perform these operations when presented with a situation involving human beings in society. The following formulation was tentatively agreed upon: first, establish point of view; second, use evidence; third, fix in time and space; and fourth, relate to total situation. It is understood that these four operations are not necessarily or even normally performed in the order given; one must move backward and forward from one to the other freely and frequently.

Students Learn by Doing

Establishing the point of view embraces the idea of formulating the question to be answered, stating the frame of reference in which the investigation is to be made, and in general deciding what is important.

The next two operations are part of the traditional methodological training of historical investigation. The techniques of discovering, selecting, evaluating, and presenting evidence and of making use of geography and chronology are comparatively well known and have been developed to a stage of disciplined critical maturity. In these matters the his-

torian, rightly, considers himself the equal of any physicist or engineer. He knows what he is doing and he can prove it. Too often, indeed, the skills of using evidence and fixing in time and space are thought of by professional historians as the whole story. Actually they are never employed in a vacuum, but have meaning only when they are preceded by some such operation as the one described above and followed by what I have called "relating to the total situation."

By this last is meant a checking and learning process, a review of all previous materials and steps to make sure no significant element has been omitted. This process will involve, above all, an attempt to establish the relevance of the particular subject in question to the totality of human experience, to place the investigation in its context.

In order to employ these skills the student must have certain information and, above all, he must know how to acquire information. It remains that the basic objective is to train students to use the critical skills characteristic of professional historians as a basis for acting intelligently in matters concerning human beings in society. The possession of these skills will make the engineer a better engineer and will at the same time help him to live his life well as a citizen and as a person. And they are fundamentally the same skills that he is trained to develop in science and technology.

In pursuing the objective sketched above, it is important that the student himself perform the desired operations. It is not enough that he witness a performance by his instructor, however brilliant, or be given a description of the requisite skills, however, elaborate. He must do it himself. It was necessary, therefore, to plan exercises in which the student operates as an historian. Two examples, one from the first and the other from the sixth week of the course, will illustrate how this was done.

The first reading assignment was in Ruth Benedict's *Patterns of Culture.* The aim was to impress upon the student the idea that culture is an integrated whole, and to lead him to see some of the techniques used for its analysis. Thereafter, the students were assigned Tacitus' *On the Germans.* No effort was made to learn in particular what he said about the Germans. Instead, his work was taken as an opportunity to apply to a particular society the general approach of Ruth Benedict. The specific student exercise was simply to answer the question, did Tacitus know what he was talking about? Discussion of the answers to the question, which were submitted in writing and several of which were read aloud, concentrated on Tacitus' proximity to the subject he was describing. From the text it could be established that he had probably never been in Germany, that his sources were questionable, and that he had an ax to grind. The students progressed from original answers based upon guess and opinion to sound deductions from statements in the text.

A somewhat more complex operation was performed by the students in the sixth week of the course in connection with the period of the Italian Renaissance. The assignment was to read selections from Cellini's *Autobiography* and Machiavelli's *The Prince* and to examine an exhibit of the art of the Italian Renaissance arranged by the department for this unit. Each student was asked to find four particular instances—one from Cellini, one from Machiavelli, and one from each of two paintings—such that a single statement about them could be made. After that he was asked to make a further statement relating these four instances to the period of the Renaissance in Italy as a whole, in other words to make a generalization.

Several students, for instance, noticed that Cellini sculptured, the figure of a Greek god, that Machiavelli referred frequently to the Roman emperors, and that Doric columns and pediments appeared in the paintings. All four instances related to classical antiquity. Some concluded, rashly, that all the people of the Italian Renaissance were dominated by the ideals

of the ancient world. Others, with greater caution and better discipline, said that in the cities at any rate the educated classes were interested in classical culture. From this example, and others which the students ingeniously discovered, the factors which limit generality were explicitly stated and considered. They learned that a particular case must be understood in its context; and that in generalizing they were in fact asserting that certain groups existed with common characteristics and that some members of these groups could be taken as typical of the whole.

Planning is Essential

It is apparent that exercises of this sort which the student performs must be planned in such a way that they lie well within the compass of his ability so that he can see their purpose and gain confidence in his own powers. Earlier exercises must, therefore, be highly refined and deliberately simplified. Particular skills must recur frequently so that the student by repetition will come to possess the habit of their use. Gradually the exercises may be elaborated, new skills introduced, several operations required in a single performance, so that in the end the student is able to stand independently and face a problem alone in all its complexity.

The sequence of the exercises within the term is worked out on the basis of a twofold plan of study. This plan of study is, on the one hand, an outline of the content of the course, dealing with western civilization and divided for convenience into a series of units. On the other hand, the plan of study is an outline of methodological skills arranged in a teachable sequence. In connection with each unit of work the staff agrees upon a minimum content which the student will be required to know, and upon an operation (or several operations) he will be required to perform. The procedure in the classroom then, in summary, is to employ the material described above in such a way that the student acts himself in a critical and controlled manner in regard to historical subjects.

Our plan is to take the student from his customary seat in the theater and lead him behind the scenes. Instead of watching a finished performance, we assist him in putting on a show of his own. We want him to be not simply a passive critic, however facile and knowledgable, but a seasoned member of the troupe who understands the whole mechanics of good production. Behind all the variety of shows from Broadway to the one-night stand we want him to see the common pattern of thought, and plan and trained analysis by which the professional job is distinguished from the amateur.

It should be emphasized in conclusion that this type of history teaching is integrated with the teaching of science and technology. The ability to make intelligent judgments is essential to good performance in each of these fields, and the criteria of intelligence are fundamentally the same. Hence, what a student does in the courses in one field reinforces and develops his capacity in the others. We in history are most concerned that he should come to see that there is an orderly, analytical way of proceeding in the field of social relations, and that he should acquire the ability, the habit, and the desire to use it. He should realize that a good professional method is the bond uniting all areas of disciplined human achievement, and he should come to possess that method.

A Study of Persistence and Performance of Engineering Students at the University of Washington*

By E. R. WILCOX

Executive Officer, Department of General Engineering, University of Washington

A discussion of our relations with secondary schools, and of the performance of their output which is our input, may be approached from several angles. The approach for this presentation will be to outline briefly the development, at the University of Washington, of coordination and selection procedures with the surrounding high schools, and then to present comparative data on the persistence and performance of students entering from high school and also of those entering by transfer from other colleges including those from our own College of Arts and Science.

For many years the faculty of the University had a standing committee on secondary schools and colleges, one or two members of which were from the College of Engineering. Three years ago the President of the University created the Office of High School Student Relation and Orientation under a director, Mr. Harold Adams, who has taken over the work of the former committee. The director together with the representatives from other colleges in the state upon invitation from the various high schools in our area spends much time the first part of each year conducting group vocational conferences and interviewing high school students who want to know what the various colleges have to offer in the professions, the applied arts, and the arts and science fields. On many occasions an engineering representative goes with the group. During the spring term, the director with a few representatives from the larger schools and colleges of the University upon request from the various high schools holds conferences with graduating seniors who are more directly concerned with how to gain admission to and how to get properly started in the college of their choice. So much for the general picture of our relations with the secondary schools.

Selection of Engineering Students

Now for a few statements of a more quantitative nature concerning selection of engineering students. During the twenties the College of Engineering accepted all students from high school who met our subject matter requirements and who had a grade point average of 2.0 (C) or better. In 1938 the admission grade point was raised to 2.2 because it was found that there was a considerable grouping of students between 2.0 and 2.2 most of whom did very poorly in their first year and therefore dropped out voluntarily or by request. The raised entrance requirement resulted in a 20 per cent decrease in enrollment for the following year. In 1947 the requirement for admission from high school for both veteran and civilian was made 2.5. This was done because of space and staff limitations in our college. At the date

* Abstract of a paper presented before the Committee on Secondary Schools ECAC at the Annual Meeting of the ASEE, June 1950.

TABLE 1

PERSISTENCE OF ENTERING ENGINEERING STUDENTS FROM HIGH SCHOOL

Based on Criteria of First Quarter Grades, Fall, 1947

	No. of Students	1st Qtr. G.P.A.	1st Qtr. Completed		2nd Qtr. Completed		3rd Qtr. Completed		2nd Year Completed		3rd Year Completed	
			No. of Students	%	No. of Students	%	No. of Students	%	No. of Students	%	No. of Students	%
1st Quartile	51.5	2.81–4.0	50	97	48	93.5	46	89.4	44	85.4	39	75.7
2nd Quartile	51.5	2.31–2.8	50	97	49	95.1	45	87.5	39	75.7	32	62.1
3rd Quartile	51.5	2.01–2.3	50	97	49	95.1	37	72.0	15	29.1	14	27.2
4th Quartile	51.5	0.00–2.0	49	95	38	73.3	21	40.8	6	11.7	4	7.8
Total	206		199	97	184	89.5	149	72.5	104	50.5	89	43.3

of this writing the entrance grade point is back to 2.2 and we are seeking for students.

In order to have a comparison with a study which was made of the class which entered in 1925 a study was undertaken of the persistence of the 1947 entering class of freshmen engineering students based upon their first quarter college grade point average. By persistence is meant the length of time that a student remains in our college. The students were divided into two groups, one (206 students) who entered direct from high school, and the other (130 students) who entered directly by transfer from other colleges. Some of the latter were ineligible to enter directly from high school because of low grades but made satisfactory grades in another college, thus gaining admission to our College of Engineering. There being no law against this procedure, a considerable number got in on good grades earned on a standard of performance which was considerably lower than that of the Engineering College; consequently, when they met higher performance requirements they fell by the wayside. As you may guess, the writer has some trouble getting rid of a slight bias against the conviction that a liberal arts course is always the best preparation for entering upon an engineering course of study.

Analysis of Results

Table I shows that about ninety per cent of the first and of the second quartile of the high school group based on their first quarter G.P.A. finished the first year with us, and that only forty per cent of the fourth quartile survived the full year. By the end of the third year about seventy-six per cent of the first quartile remained while only about eight per cent of the fourth quartile were

TABLE 2

PERSISTENCE OF ENTERING ENGINEERING STUDENTS TRANSFERRING FROM OTHER COLLEGES

Based on Criteria of First Quarter Grades, Fall, 1947

	No. of Students	1st Qtr. G.P.A.	1st Qtr. Completed		2nd Qtr. Completed		3rd Qtr. Completed		2nd Year Completed		3rd Year Completed	
			No. of Students	%	No. of Students	%	No. of Students	%	No. of Students	%	No. of Students	%
1st Quartile	32.5	2.81–3.8	31	95.5	30	92.2	28	86.1	26	80.0	22	67.6
2nd Quartile	32.5	2.11–2.8	31	95.5	29	89.1	27	83.0	14	43.0	9	27.7
3rd Quartile	32.5	1.91–2.1	31	95.5	28	86.1	17	52.3	8	24.6	5	15.4
4th Quartile	32.5	0.00–1.9	30	92.2	25	77.0	5	15.4	3	9.2	3	9.2
Total	130		123	94.6	112	86.3	77	59.3	51	39.4	39	30.0

TABLE 3

PERSISTENCE OF STUDENTS ENTERING FROM HIGH SCHOOL AND OF TRANSFER STUDENTS, FALL, 1947

Criteria Based on A.C.E. Weighted Total Scores (Percenitles for U. of Wash. Freshmen)

		A.C.E. Weighted Total	Total Student Scores	1st Qtr. Completed		2nd Qtr. Completed		3rd Qtr. Completed	
				No. of Students	%	No. of Students	%	No. of Students	%
1st Quartile	H.S.	78–99	40	40	100	38	95	36	90
	Trans.	89–99	17	17	100	16	94	13	76.5
	All-U	75–99							
2nd Quartile	H.S.	63–76	40	40	100	37	92.5	35	87.5
	Trans.	58–88	17	17	100	17	100.0	11	64.5
	All-U	50–74							
3rd Quartile	H.S.	44–61	40	40	100	38	95	33	82.5
	Trans.	35–57	17	17	100	16	95	15	88.3
	All-U	25–49							
4th Quartile	H.S.	0–42	40	40	100	35	87.5	34	85.0
	Trans.	6–34	17	17	100	17	100.0	11	64.5
	All-U	0–24							
Total	H.S.		160	160	100	148	92.5	138	86.3
	Trans.		68	68	100	66	97	50	73.5

still with us. Table 2 shows that approximately eighty-five per cent of the first and of the second quartile of the transfers based on their first quarter G.P.A. were in school at the end of the first year while only fifteen per cent of the fourth quartile survived the year. By the end of the third year about sixty-eight per cent of the first quartile remained while only nine per cent of the fourth quartile were present.

A similar persistence study was made with quartiles based on the weighted A.C.E. college aptitude test scores. Table 3 shows clearly that this basis for predicting persistence in engineering is entirely unsatisfactory. Students succeed best who have the most clearly defined objectives and most active motivation. Ability to read or reason apparently is neither a measure of clearly defined objectives nor of motivation. Achievement test scores combined with high school grades in certain groups of subjects are a much better measure for prediction, according to Dr. August Dvorak, Director of Admissions Research at the University of Washington, who is making a study for the entire University of the 1947 entering group.

Finally a study of the quality of performance in terms of G.P.A. by quartiles for the first quarter in Engineering was made for each of the two groups (high school and transfers). The high school group practically all came from the upper half of their high school graduating class. Table 4 shows what percentage of each of the four quartiles based on the first quarter G.P.A. came from the first and the second quartile group of high school graduates.

From this data it is clear that a man in the first quartile of his high school class has four out of five chances of placing in the top quartile of his college

TABLE 4

1st Quarter Scholastic Performance, 199 High School Students, Fall, 1947

Criteria Based on Quartile in High School Graduating Class

1st Quarter U. of W. G.P.A.	High School Quartiles	
	1st	2nd
1st Quartile	78%	22%
2nd Quartile	50	50
3rd Quartile	44	56
4th Quartile	30.5	69.5

group at the end of the first term compared to one chance in five for the man from the second quartile. Also the man in the second high school group has two chances in three of placing in the fourth grade point quartile compared with one in three for the man in the first high school group. Quite evidently this type of high school grouping in our area is significant only for forecasting the top and the bottom performers and does only a moderately good job in this respect.

In order to compare the performance of the transfer students with that of the high school entrants the former were divided into upper and lower halves on the basis of their previous college G.P.A. Table 5 shows what percentage of each of the four quartiles based on first quarter G.P.A. came from the upper and lower half of the transfers. Discrimination between the two groups of transfer students is not as marked as between those from high school. The top half of the transfers furnished nearly two-thirds of the first quartile group and only slightly over one-third of the fourth quartile group. The second and third quartile grade group came about evenly from the upper and lower halves of the transfers, paralleling almost exactly the performance of the high school group in this respect. Nearly two-thirds of the fourth quartile grade group came from the lower half of the transfers. The fourth quartile grades for both high school and transfers were all below "C." (See second column Tables 1 and 2.)

TABLE 5

1st Quarter Scholastic Performance, 116 Transfer Students, Fall, 1947

Criteria Based on Previous College G.P.A.

1st Quarter U. of W. G.P.A.	Previous College G.P.A.	
	Upper 50%	Lower 50%
1st Quartile	62%	38%
2nd Quartile	51.8	48.2
3rd Quartile	48.2	51.8
4th Quartile	38	62

From a study of the data here presented, it is evident that admission to engineering colleges on the basis of high school grades even when the grade point average is set fairly high does not differentiate markedly between those who will continue to graduation in engineering and those who will not. It is also clear that the first quarter grade point average in the Engineering College gives a much better criterion for determining the likelihood of ultimate graduation. We should all like very much to have, if possible, some criteria to apply to the student before he enters engineering that would tell us whether his chances were ten to one or one to ten that he would succeed in this field. Many studies have been and are being made on this subject. Dr. Edmund Dudek, Director of our Testing Bureau, in cooperation with the General Engineering Department made a thorough investigation of the performance of the group entering in 1947—approximately the same group used for this persistence study. He found that the high school grade point average did not predict the first year engineering grade point average as well as a single 45-minute test in mathematics (Co-op Test Service—College Math), and also that this Co-op Math Test predicted the first year engineering grade point average exactly as well as the Total Score of the 4-Part Pre-Engineering Inventory Test, which took one-half day to adminis-

ter. From a regression equation using test scores from six predictive variables; PEI-part 2, PEI-part 3, ACE-Q score, ACE-L score, Co-op Math, and high school G.P.A., an "R" of 0.653 was obtained with grade point average for the year. This is fair but not good enough to be used for college admission. Some reliable measure of interest and motivation is very much needed.

It is quite evident that prediction of performance of engineering students at the University of Washington has not yet reached the state where it can be used arbitrarily to exclude students. Real progress is being made, however, and the results which are now obtainable can be used to very good advantage in counseling our freshman engineers, and they are being so used in our department.

Thermodynamics Summer School

June 28–July 7, 1951, Michigan State College

A Summer School in Thermodynamics will be held at Michigan State College, East Lansing, Michigan, June 28–July 7, 1951, at the close of the Annual Meeting of the ASEE. Methods of better teaching of the elementary thermodynamics will be presented as well as modern developments in the field of thermodynamics and a little on advanced theory. In addition, more background material for the teacher will be provided.

The following is a tentative program: June 28, "Leading the Student of Thermodynamics to Think," "Teaching the Concept of State Properties, Boundaries, Systems, etc."; June 29, "First Law of Thermodynamics," "Effective Presentation and Modern Approach to the Second Law of Thermodynamics," "Energy Transfer from the Laws of Thermodynamics," "Fluid Mechanics and Thermodynamics"; June 30, "Availability and Reversibility," "Mathematical Approach to Kinetic Theory of Gases," "Kinetic Theory of Gases and Thermodynamics"; July 2, "Basic Physical Chemistry for Thermo Teachers," "Physical Chemistry and the 1st and 2nd Law of Thermo," "Integration of the Physical Chemistry Approach to Thermodynamics"; July 3, "Visual Aids in Teaching Thermodynamics," "The Atomic Age: How to Equip Engineering Students for It," "Thermodynamics of Gasoline Engine Cycles"; July 4, "Thermodynamics of Vapors: Preparation of Vapor Tables"; July 5, "Combustion Theory: Combustion in Stationary Boilers," "Steam Turbines and Power Plant Design"; July 6, "Theory of Jet Engines," "Combustion in Jet Engines"; July 7, "Gas Turbine Design," "Compressor Design," "Compressor Flow."

A registration fee of $10 will be charged.

The Development of a Graduate Program in Engineering Mechanics*

By D. H. YOUNG

Professor of Engineering Mechanics, Stanford University

On the engineering corner of one of our large midwestern universities there is a plaque, cast in bronze and set in stone, on which is inscribed the following motto: "When theory and practice disagree, use horse sense." Without meaning to cast discredit on this philosophy, I would like to imply that it may no longer strike the keynote of our times. The horse is almost an extinct animal in our modern civilization and for better or for worse we seem to be more deeply committed to science today than ever before in the history of mankind. Let me, then, take the liberty of offering a revision of the motto and state it this way: "When theory and practice disagree, use more theory." To uphold this viewpoint is, as I see it, the major role of a program of graduate study in engineering mechanics in our present day system of engineering education.

In discussing the development of such a program of graduate study, I am not under the misapprehension that there is anything particularly new about the subject, or for that matter about the ideas which I have collected upon it for this discussion. Mechanics is certainly as old as engineering itself and one could cite many eminent men from previous centuries who would unquestionably be classified as specialists in the field today. In fact, it owes its very existence to such men as Galileo, Newton, the Bernoulli brothers, Lord Rayleigh, Otto Mohr, Lagrange, and a host of others. None the less, the emergence of the subject as a specialized field of engineering education in this country has been a comparatively recent development. Statistics from the U. S. Office of Education show that in 1933–34, only twenty-five students were working for the M.S. degree specifically in engineering mechanics and that nine such degrees were conferred, while only seven students were similarly engaged in work toward the doctorate. In 1948–49, the same statistics show that as many as 25 American engineering schools already had such graduate programs under way and that 207 students were working for the M.S. degree with 62 such degrees conferred. The same figures for Ph.D. work were 73 enrolled and 8 degrees granted. This represents roughly a tenfold increase in a period of 15 years. Even making allowance for the overall increase in engineering education during the same period, it seems clear from such statistics that the relative importance of mechanics as a specific division of graduate study is growing and that in the future this growth can be expected to continue.

While it is difficult to run down specific facts in regard to the history of this movement, I believe it safe to say that this growing interest in engineering mechanics as a field of graduate study in our American universities can in no small measure be attributed to the influence of Professor Stephen P. Timoshenko, who first came to America in 1922 and began

* Presented at the Mechanics Division conference at the annual meeting, Seattle, Wash., June 22, 1950.

his career as an American teacher at the University of Michigan in 1927. I take the opportunity here to pay tribute to this man for his very profound influence on our system of engineering education.

At Stanford, the newly formed "Division of Engineering Mechanics" has been a post-war development. This is not to say that we had not previously carried on graduate work in this field under both Civil and Mechanical engineering as no doubt many engineering schools are still doing. But the numbers of students really specializing in mechanics were small and the degrees granted would not have shown up in the statistics quoted earlier because they were not specifically ear-marked mechanics. At the present time, after two years of operation, we have about 30 students working for the M.S. degree and 16 for the Ph.D. This June (1950), 6 master's and 5 doctor's degrees were granted.

The division is organized solely on the graduate level and does not enjoy departmental status, being rather a joint responsibility of both the Civil and Mechanical engineering departments. It has no budget and all of the faculty members concerned with it are carried by one or the other of these departments. We find that this type of organization has its advantages, particularly in the fact that it necessarily keeps engineering mechanics in close association with the more professional aspects of both Civil and Mechanical engineering and avoids unnecessary duplication of courses, equipment, and personnel. It also serves to hold these two departments in close contact with each other, giving them an overlapping field of common interest.

Major Elements of Graduate Study

Before going into more detail, let me set forth what we believe to be the major elements of a well integrated program of graduate study in engineering mechanics, as follows:

1. A well qualified faculty, consisting of at least several experts in the various sub-fields of mechanics.

2. An adequate curriculum, containing enough courses to cover the various fields and including at least some of the more newly developing ones.

3. Plenty of research activity—course work alone is not enough and will become stale without the support of research.

4. Students in sufficient numbers to justify the above outlay in the eyes of the administration and to maintain a lively spirit of competition.

5. Adequate physical facilities.

On the whole this is likely to add up to a rather expensive operation in relation to the numbers of students involved which must necessarily be limited, if not small. Fortunately there are several saving features which make it possible. First, those faculty members primarily responsible for the program also teach closely related courses in either Civil or Mechanical curriculums and thereby spread their cost to the University over a larger area and one where students are more numerous. Again, and even more important in our experience, the government sponsored research contracts have made it possible to expand the program and integrate the whole operation. 1). These contracts furnish the research activity so essential to the life of the program. 2). They help subtantially in permitting the University to extend its faculty and thereby obtain the specialists required to give all phases of course work in mechanics. 3). They help subsidize graduate students who could not otherwise afford to devote several years to graduate study. 4). They furnish expensive experimental apparatus that the University might not otherwise be able to buy. Clearly these four aspects of the government research contract make it an extremely important ingredient in the program. Without government aid in the form of the research contracts, the division of engineering mechanics at Stanford could not have been nearly so effectively organized as it has been.

Another development in the program at Stanford that has proved to be an ex-

cellent supplement to the research contracts and a boon to the program as a whole has been the creation of a number of part-time teaching assistantships. These assistantships, mostly in undergraduate mechanics, also serve several useful purposes. They help again to subsidize good graduate students and at the same time they free regular staff members to devote a part of their time to directing one of the research programs. They also give graduate students valuable teaching experience and since many of them aim at teaching as a career, this seems a worth while element in their training. Thus we have found ourselves engaged in a minor way in operating a teacher training program in conjunction with the mechanics program itself. This has proved a very interesting activity and, I believe, a very worth while one. If time permitted I should like to enlarge somewhat on this phase of the division's activity but one point worthy of mention in passing is the value that the graduate student gets from teaching in strengthening his own grasp and command of the more elementary phases of mechanics. The importance of this to his own program of graduate study should not be underestimated.

There may be those who will question the advisability of entrusting the teaching of such important subjects as undergraduate mechanics to young and inexperienced teachers. However, let us remember that youth and enthusiasm as well as a fresh and unspoiled viewpoint are powerful factors in successful teaching and it behooves those of us who have been at it for a long time not to be too quick to assume that the advantages all lie on the side of age and experience.

Master's Degree Program

In discussing the content of a graduate curriculum in engineering mechanics, I should like to begin with the M.S. program, assuming that by this we mean the first year of graduate work. In our present program at Stanford, we have settled on 45 quarter units of course work without a thesis. Some may evidence surprise at this quick dismissal of the thesis for a graduate degree in a field of study so likely to lead to a career in research. Admittedly, some experience with an independent investigation of a new problem would be highly desirable but there are several real and not easily dismissed obstacles to such a course of action. Firstly, with a sizable group of students on hand in the master's program, the mere chore of dividing up the supervision of so many theses among a limited faculty becomes prohibitive. Also, and more important, it can be seriously questioned whether or not a student just beginning graduate study in a field as difficult as mechanics has the necessary background to immediately begin research activity in that field. In fact, our experience has been that even Ph.D. candidates find considerable difficulty in finding a subject and getting into the spirit of independent research and need a great deal of guidance at the beginning of this experience. Obviously then, the master's thesis could be little more than a study of some existing theory or method of analysis already developed. Admitting this, most of the arguments in its favor fall and we have felt that it is better to ask the master's candidate to concentrate on course work with perhaps a few units of directed reading in some chosen field of interest.

Before proceeding to an examination of the master's program in detail, I should like to comment on the many new developments in the field of engineering mechanics. To mention but briefly some of the more outstanding of these, we have the newly developed high speed aerodynamics as well as great expansion in general in the field of fluid mechanics; many new developments in experimental stress analysis, today practically a field in itself; the new and growing theory of plasticity; and last but by no means least the widespread interest in non-linear mechanics with all of its associated control problems and the marriage of electrical and mechanical systems which threatens to make electric circuit theory as much

a part of mechanics as the theory of elasticity. All this in addition to the more established fields of vibration theory, stability problems, elasticity, etc., clearly calls for course requirements in a much wider variety of subjects than was considered essential even so few as ten years ago. And moreover, taken all together, they put a much greater emphasis on the importance of mathematics in this general field than ever existed before.

Taking into consideration the magnitude of this expansion, it seems clear that exhaustive formal course work in all of these newer fields is hardly possible or desirable for the master's program, but to enable Ph.D. candidates to make profitable use of a second year of course work, at least some formal courses in these newly developing fields are highly desirable. Our own policy at Stanford has been to start with those courses that we already had in operation and gradually build up the courriculum as we go along. In this regard we have already made some progress. We now have a total of 50 units of established course work in engineering mechanics exclusive of closely related courses in Civil and Mechanical Engineering. Starting next year (1950–51) we will introduce a second year course in Hydro- and Aerodynamics, a group of courses in non-linear mechanics running through the three quarters, and one second year course in Applied Elasticity. Such a block of courses in engineering mechanics serves more than one purpose. Aside from their interest in E.M. majors, they greatly enhance the offerings available to graduate students in other departments, notably those working in Structures and Aerodynamics and to some extent in Physics, Metallurgy, and Mathematics.

As to the 45 units of course work required of the master's candidate, these have been specified in four sub-fields as follows:

a). 6 units in elasticity,
b). 6 units in dynamics,
c). 6 units in fluid motion,
d). 6 units in mathematics.

This is intended to introduce the student to all of the branches of engineering mechanics and help him decide his own major field of interest for Ph.D. work if he decides to go beyond the M.S. degree. It is also calculated to represent an absolute minimum of requirements in each field. In addition to these 24 absolutely specified units, another 12 units of mechanics electives are required but the actual courses are not specified. Finally the student is allowed 9 units of absolutely free electives, making in all 45 units. While these 9 units may also be taken in mechanics, the student is urged here to give some breadth to his training. It is felt that courses in electronics, modern physics, or metallurgy are representative of the kind of approved electives but if the student wishes to use them for study in the history of art, he would be allowed to do so. Our own experience has been that most students need to be urged to depart from a steady diet of mechanics rather than held to it. From the foregoing remarks it must be clear that engineering mechanics is already such a broad field that the master's program can claim to be little more than an introduction to the subject and an opportunity to test one's aptitude for it. As a mark of mastery in the field, the M.S. degree leaves much to be desired.

Doctorate Program

The Ph.D. program, of course, entails two years' work beyond the M.S. degree of which, roughly speaking, one is devoted to course work and one to the thesis. Those students who need financial assistance will usually be employed part time on one of the research programs in which case his work for the project and his own thesis work are rather likely to overlap somewhat. It is here that the importance of having a good and lively variety of research programs becomes apparent. In this respect, we are particularly fortunate in our present program at Stanford. There are now no less than nine such research programs under way either in engineering mechanics proper or

in closely related fields of civil and mechanical engineering. They include programs, in *Stability Problems, Vibration Problems, Non-Linear Mechanics, Plasticity, Column Research, Airplane Structures, Fluid Mechanics,* and *Aerodynamics.* In addition, there are some students doing their thesis work independently of any research programs. This is particularly advantageous for those who do not require financial assistance or are getting it through the teaching assistantship program.

There is one general aspect of the Ph.D. program worthy of comment, and that is the question of a minor. The University Graduate Study Committee at Stanford has recently abolished the requirement of a minor in all Ph.D. programs and this seems to be a characteristic trend throughout the country. Since most departments require for a minor approximately the equivalent of a master's degree in that department, the argument was that this detracted too much time and energy from the major work. However, with the waiving of the minor as a university requirement, each department has been charged with the responsibility of insuring that the student's program shows some breadth of knowledge without at the same time becoming disjointed in its overall objective. In assuming this responsibility, we have tried to meet the spirit of a minor by the recommendation to the student of a systematic block of courses in the mathematics department. However the natural objection may be raised that mathematics in relation to mechanics is not a minor at all but rather a very essential element in the process of specialization in a narrow field.

To what extent we should go in destroying, or allowing to be destroyed, the classical concept of a minor seems worthy of careful consideration. It it useless to deny that there is a strong trend toward more and more narrow specialization in all Ph.D. work. In mechanics this is a natural consequence of the rapid expansion of the field already referred to. While there are some who decry this trend as endangering the real purpose of education, I cannot become too greatly disturbed over narrow specialization in graduate study. It seems that four years of general college training should be sufficient background upon which to build one's general education and that after this it is time to specialize or run the risk of becoming a perennial student Thus, I believe that the extent of breadth of training in graduate study may safely be determined entirely by the dictates of the major.

In closing, something should be said about the end-product of this overall program; namely, the young man with a Ph.D. in engineering mechanics. What are the opportunities open to him and how limited is the market for his services?

The answers to the first question are fairly obvious. Certainly he is not likely to go out as a practicing engineer in the usual sense of the word, but rather we may look to him as one who will contribute to the progress of engineering science as a whole although it be only in a small way individually. As to jobs, he can choose between teaching, research, or analysis and design not of a routine nature. Regarding the question of the saturation point of the market, time, of course, will prove to be the better prophet, but it seems reasonably sure that if the standards are kept high, as they must be, then there probably cannot be such a thing as an over-production of Ph.D.'s in this field. With the ever increasing scientific complexity of our modern world, the new problems awaiting attention bid fair to keep well in advance of the production of men trained to cope with them.

Engineering Economy—What It Is and Its Place in Engineering Curricula*

By H. G. THUESEN

Head, School of Industrial Engineering, Oklahoma A. & M. College

As its name implies Engineering Economy embraces two fields of investigation, namely engineering and economics. In this respect it is similar to such other engineering subjects as sanitary engineering, engineering physics and more recently bio-mechanics. These and other similar subjects have come into being as the scope of the engineer's activities has made them desirable.

It is very difficult to define even one field of investigation and it is practically impossible to formulate an all inclusive definition of a subject which abstracts certain elements, based on their usefulnes, from two or more fields of investigation. Nevertheless, I shall attempt to give a workable definition of *engineering economy*.

Definition of Engineering Economy

The noun economy means management with thrift. This meaning coupled with the term engineering implies application of engineering with thrift. The function of engineering is to serve mankind. The term engineering economy embodies the idea of maximum service per unit of cost, through engineering.

The primary purpose of engineering economy techniques is the quantitative evaluation of engineering proposals in terms of economic worth and cost. A second function of engineering economy techniques is to place economic evaluation of different engineering proposals on equivalent bases for comparison. Engineering economy techniques are an extension of the quantitative approach of engineering to embrace not only the physical environment, but also the economic environment.

The philosophy of engineering economy embraces the idea that the engineer must work in two environments, namely the physical and the economic; that there is uncertainty relative to the economic outcome of all proposals; and that certainty of decision can be improved by careful analysis.

I think of engineering economy as a tool subject which may be defined as a body of knowledge, techniques and practices of analysis and synthesis for the quantitative evaluation of physical products and services in terms of utility and cost.

In my opinion these concepts were first embraced in a practical textbook for instruction of engineers on publication of *Principles of Engineering Economy* in 1930 by Professor Eugene L. Grant at Stanford University. Engineering education is indebted to Professor Grant for delineating a subject of instruction whose value is attested by the increasing number of engineering curricula which include it.

Economics and Engineering Economy

In the next paragraphs I shall compare the general subject of economics with engineering economy.

* Presented before Engineering Economy Committee of the ASEE at the Annual Meeting, June 20, 1950, Seattle, Washington.

Economics is often defined as a study of man's activity in using scarce means to satisfy his wants. Economics is concerned with some aspects of capacities to produce, quantities and types of goods and services produced, the flow of products and services to those who consume them, the cost and income arising from production activities, and the disposition of income.

Economics rests upon utility. Utility is the want-satisfying power of goods and services. The utility that goods or services have for an individual is subjectively determined by him. For example, even engineers purchase cars on the basis of the subjective appeal of their color, line and performance at least to some extent and not wholly upon objective consideration. It is the aggregate of subjectively ascribed utilities and their effects that are given attention in general economics. Thus the subject of economics rests upon the vagaries of people.

Though the engineer also must consider economic phenomena his viewpoint differs from that of the economist. Whereas the economist regards tools of production as abstractions they are concretely considered by the engineer. For example, the economist speaks of the capacity of the nation's blast furnaces as being a certain number of tons of pig iron at a certain average cost per ton. But to the engineer each blast furnace is a separate distinct entity, composed of many parts designed to resist forces, heat, corrosion, and so forth. Each part is the result of the application of engineering technology. In the operation of the blast furnace the economist is concerned largely with the rate of production and the cost of output per ton. For the engineer the operation of the last furnace means the scheduling of the inflow of air, ore, fuel and flux, the chemistry of their combination, applications of power as well as direction and management of men. To be successful all details of the design, construction and operation of the blast furnace must be precisely in accord with immutable physical laws. But it is not sufficient that the pig iron be produced. It must be produced at a cost that is in keeping with the existing economic environment which establishes the price at which it can be sold. To be successful, engineering must surmount limitations imposed by both the physical environment and the economic environment.

Since the primary objective of engineering is the satisfaction of human wants, the economy of utility invariably takes precedence over physical economy. This is an idea that engineers should understand and appreciate.

In engineering economy we are concerned with the future income and cost of providing physical products and services. Income and cost are analogous to the familiar output and input of engineering. The ratio of output to input of physical units is a measure of the physical desirability of an engineering application. The ratio of income to cost is a measure of the economic desirability of an engineering application. The former ratio is always equal to unity or less. The latter ratio may have any value but only when its value is greater than unity is an engineering venture profitable.

Where the objective of engineering applications is utilitarian, which is nearly always the case, we are interested in the ratio of output and input of physical units only to the extent that it has a bearing on the ratio of income to cost.

It should be emphasized that engineering economy studies are primarily concerned with the future. Decision to undertake engineering ventures are made in the present hope that a profit will result in the future. The success of ventures hinges upon the relationship of future costs and future incomes. Ordinarily, neither future costs nor income can be known with certainty. Therefore the decision to act must be based, in part, on judgment. Engineering economy analyses are aids to judgment. Engineering economy analyses aid judgment by providing a clear picture of the combined effect of the elements of income and the

elements of cost, including depreciation and inteerst that are estimated to apply to a situation under consideration.

This is comparable to arriving at the volume of a room by determining, mathematically, the combined effect of its estimated length, breadth and height as contrasted to estimating the room's volume directly.

Objectives of Engineering Economy Courses

In my opinion the three principal objectives of a course in engineering economy are to equip the student: (1) to develop opportunities for the profitable application of engineering, (2) to evaluate the economic worth of engineering proposals and (3) to interpret the worth of engineering proposals to prospective users.

In developing opportunities for the profitable application of engineering the engineer accepts a creative roll to broaden his usefulness. In this roll he seeks to discover unsatisfied needs of people that can be satisfied by engineering applications. For example, a civil engineer may discover a new combination of materials for making a concrete that has qualities which satisfy needs of people, that can be produced at low enough cost to be acceptable, and that has desired physical properties of strength, durability, abrasion resistance and so forth. In this example the engineer has been creative in two environments. In the economic enviornment he has discovered a utility that provides satisfaction for people greater than its cost. In the physical environment the engineer has discovered a combination of physical materials that creates a concrete of new physical properties. It is important that the engineer accept a creative roll to extend the application of engineering for he not only benefits mankind but thereby also extends the field for engineering.

Engineering applications are successful only to the extent that they are acceptable by those who must ultimately pay for them. Thus economic evaluation of engineering proposals is inescapable. The engineer has the choice of evaluating his proposals in terms of economic worth on paper before they are put into effect or of evaluating them by trial and error at much greater cost. Since engineering applications are accepted or rejected on the basis of their economic worth and their cost, the engineer can increase the value of his services by extending the engineering approach to include an evaluation of worth and cost.

In some cases it is undoubtedly true that people will wear a path to the door of the inventor of a better mouse trap. But engineering application usually must be interpreted to consumers in terms of economic worth. People do not buy an automobile for its fine pistons, ignition system and steering gear but for transportation, comfort and prestige. Advertisers recognize this and describe automobiles in terms that have meaning for prospective consumers. It must be realized that engineering is not an end in itself but a means to an end. Engineering data are often of little help to consumers in arriving at the utility of the products of engineering. As a result many worthwhile engineering proposals are rejected and there is much misapplication of engineering because engineers fail to explain their work in terms that can be appreciated by those with whom decisions rest.

Curriculum Considerations

In considering the place of engineering economy in engineering curriculum one cannot be unmindful of the difficulty of adding new subjects. Subjects can no longer be added because they are of value but only because they are more useful than the subjects they will displace.

Since engineering economy is concerned with both physical and economic factors, it seems reasonable that it may prove of most value to those engineers who, after graduation, engage in activities which embrace both fields. A large percentage of graduates of all engineering

curricula now find employment which ultimately leads to supervisory and managerial activities. Sales and promotional work claims another large percentage. Since remuneration for such activities is relatively high, it is reasonable to suppose that graduates qualified to perform them are in relatively short supply. Students interested in these activities are quick to recognize the value of engineering economy. If reasonably well taught, a course in engineering economy may be expected to enjoy high student interest because of its useful concepts and quantitative analyses.

Thus the place that engineering economy should have in engineering curricula may well be decided by making it an elective course of Junior or Senior level open to students of all engineering curricula. Where this has been done the usual experience has been for the enrollment in engineering economy to increase rapidly.

Summer School
Engineering Drawing Division
June 21-26, 1951

The Executive Board of the ASEE has formally approved sponsorship of the Engineering Drawing Division Summer School to be held in connection with the Annual Meeting at Michigan State College. This will start four days previous to the Society meetings which is Thursday, June 21, 1951, and conclude with our regular sessions allotted during the following week.

The general theme of this school will be "Improving our Status as Teachers of Engineering Drawing" treated on a basis of:

(a) Meeting curriculum requirements
(b) Teaching methods by lecture demonstrations
   1. Basic Drawing
   2. Descriptive Geometry
   3. Advanced Drawing
   4. Elementary and Advanced Graphics
(c) Industrial applications

The local committee at Michigan State College making arrangements at East Lansing for this Summer School consists of Professor C. L Brattin, Chairman; O. W. Fairbanks; N. R. Sedlander; R. O. Ringoen (all of Michigan State College); Professor Philip O. Potts, University of Michigan; Professor Ralph T. Northrup, Wayne University; and Dean Jasper Gerardi, University of Detroit.

The Division is planning to exhibit student work in engineering drawing, course outlines, foreign drawings, drawing instruments and materials, visual aids and other displays which will be of interest to engineering teachers.

A cordial invitation is extended to all members of the Society who are interested in this program.

RALPH S. PAFFENBARGER, *Chairman*
Division of Engineering Drawing, ASEE
The Ohio State University

Coordinating Calculus Instruction in the Engineering Program

By CHARLES A. JOHNSON
Assistant Professor of Mathematics, University of Missouri

The purpose of this article is to give a brief description of a study made at the University of Kansas in the spring semester of the academic year 1949–50 entitled, "An Investigation of Coordination between the Teaching of Calculus and the Teaching of Other Subjects in Undergraduate Engineering Curricula."

The principal investigative techniques employed in this study were: (1) A rating form on which the members of various engineering departments who were teaching courses for which elementary calculus is a prerequisite indicated the relative importance of the topics normally taught in elementary calculus. (2) A questionnaire in which the members of the mathematics department who taught elementary calculus indicated the content of the course as they taught it and the method of instruction employed. (3) A calculus proficiency examination administered to junior and senior engineering students who had completed study of calculus.

Engineering Instructors' Ratings

Considering the ratings as a whole, *the process of finding derivatives was considered most important* while the solution of elementary types of differential equations was considered least important. Newton's Method for approximating roots and the First Proposition of Pappus received very low ratings. *Aeronautical engineering* instructors rated *derivatives* and their applications to time-rate problems, velocity and acceleration, *maxima and minima,* and integration applied to the determination of fluid presure very high; they gave low ratings to Newton's Method, simple differential equations, curve tracing, and the Theorem of Mean Value. *Chemical engineering* instructors assigned high ratings to *derivatives, maxima and minima,* use of a table of integrals, higher derivatives, partial derivatives, and work and fluid pressure problems; low ratings were given such topics as volume and area by double integration, differential equations, *centroids and moments of inertia,* and *difficult processes of integration and differentiation. Electrical engineering* instructors rated highly such topics as *maxima and minima, derivatives, area,* the differential, integration devices, motion, length of a curve, *infinite series, simple differential equations,* and use of a table of integrals; low ratings were assigned to *centroids and moments of inertia,* fluid pressure, differential equations of higher order than the second, volumes, and curvature. High ratings were given by *mechanical engineering* instructors to the differential, work, *derivatives, maxima and minima,* velocity and acceleration, and *moments of inertia;* relatively low ratings were assigned to such topics as the First Proposition of Pappus, area in polar coordinates, surface of revolution, *infinite series,* curvature, and finding the angle of intersection of plane curves. *Applied mechanics* instructors assigned high ratings to *centroids and moments of inertia, derivatives,* velocity and acceleration, use of a table of integrals, work, *maxima and minima,* and

the Second Proposition of Pappus; many topics covered principles "never used"—such as most material on infinite series and simple differential equations.

The *civil engineering* department made no ratings because the chairman of the department indicated that while he wanted the student to have calculus, practically no use of it was made as such in undergraduate engineering courses. Ratings were not requested from members of the *architectural engineering* staff although a group of students in this curriculum did participate in the study by taking the calculus proficiency test.

The Instructional Program in Elementary Calculus

Elementary calculus is taught in the College of Liberal Arts at the University as an eight semester-hour course—five for Calculus I and three for Calculus II. Students normally enroll in it at the beginning of their sophomore year after completing algebra, trigonometry, and analytic geometry. Instruction is handled by the regular members of the mathematics staff, some of whom teach only one or the other of the two courses. An outline is provided by the chairman of the department for the first course but not for the second. Engineering students are taught in separate sections.

The substance of the replies to the questions that dealt with *method* may be summarized briefly thus: (1) In answer to a question inquiring about the per cent of time devoted to *lecturing,* the replies ranged from "as little as possible" to "ninety-five plus" per cent with the majority lying in the range of thirty-five to fifty per cent. (2) *"Board work"* occupied about fifty per cent of the class time. There was about an even division between those utilizing this time for putting previously prepared problems on the board and those using it to work on problems arising out of new theory. (3) *Class discussion* took up anywhere from "zero per cent" of the time to "most of the period" with the average instructor using twenty to thirty per cent of the period for this purpose. (4) Most instructors taught calculus to engineering sections as a *"tool subject,"* not in the narrow sense of memorization and application of formulas, but in the sense of including application problems of interest to the engineer and teaching the course with the ends of the engineer in view. In addition it was found that six of the thirteen instructors who made replies had revised the outline for the first course by *delaying instruction in integration* until the processes of differentiation had been thoroughly covered, thus defeating the textbook author's (Love) purpose of introducing integration early so that the student would have had instruction in it before being required to use it in other engineering courses and physics.

The *content of the first course* in calculus may be roughly characterized as follows: About 7% of the time is devoted to finding first and higher *derivatives of algebraic and trigonometric expressions;* approximately 11% of the time is spent on *applications of derivatives* including, of course, finding maxima and minima. *Integration of simple algebraic expressions* including applications to plane areas takes up about 10% of the time while another 10% is spent on *derivatives of transcendental functions.* About 12% of the time is devoted to the study of *more difficult integration processes,* including trigonometric substitution and integration by parts, while approximately 17% of the time is taken up by *applications of integration.* The remainder of the time is devoted to miscellaneous topics which cannot easily be categorized but they are the usual ones listed in most standard texts in elementary calculus.

In the *second course* about one-third of the time is spent in finding *centroids* and *moments of inertia* by single integrals; *infinite series* takes up approximately one-fourth of the time; another one-fourth of the time is devoted to the study of *multiple integration* and its application to areas, volumes, centroids, and

moments of inertia; the remainder is taken up in the study of fluid pressure, approximate methods of integration, partial differentiation, and finding the normal line and tangent plane to a surface. It should be added that only one instructor touched upon differential equations.

The Calculus Proficiency Examination

The purpose of the proficiency examination was to determine the extent to which the most rudimentary techniques and principles of elementary calculus were functionally operative among undergraduate engineering students who had completed study of calculus and were currently enrolled in courses on the junior and senior level.

The test was of fifty minutes duration and contained fifteeen problems, nine requiring differentiation and six integration. No topic from either infinite series or differential equations was represented in the test. Administration of the test was in most cases left up to the regular classroom instructor who was instructed not to announce it in advance. All engineering groups took the same test—the total number being 526. Analysis of the scores achieved on a psychological test and on the mathematics entrance examination revealed that all groups were essentially on a par as far as these two criteria are concerned. Since the problems of the test were relatively short and required few skills not learned in the calculus course itself, each problem was scored either right or wrong, thus making 15 the highest score attainable.

The *electrical engineering group,* which had an extensive background in engineering courses for which calculus is prerequisite as well as the advantage of study of differential equations, performed well in comparison to other groups, achieving a mean score of 8.3. The majority of this group, however, either incorrectly solved or omitted more than half the problems of the test. They had more success with an application where integration was required than they did with an equally simple situation requiring differentiation. Although it might be expected that those completing their calculus more recently would excel, it was found that this was not a significant factor even though there was a preponderance of seniors in the low group (scoring 5 or less). The high group (scoring 12 or above) had considerable difficulty with the applications of either differentiation or integration—for the low group the applications were practically impossible. It was found that the high and low groups were very uniform in their background in engineering courses for which calculus is prerequisite.

The mean score for the *mechanical engineering group* was 5.6. Like the former group this group was more able to solve an application problem requiring integration than the one involving differentiation. The lower twenty-three per cent (scoring 3 or less) had retained only one skill to any appreciable degree —that of differentiating simple algebraic expressions. The most that one can say is that this group exhibited moderate facility in differentiating algebraic expressions and some ability to perform simple processes of integration. The application problems proved extremely difficult for the entire group.

The *chemical engineering group* achieved a mean score of 8.1. This group had a grade-point average in calculus considerably above the other groups. Almost every student in this group had completed or was currently enrolled in three engineering courses for which calculus is prerequisite. The only residual skill evident among the lower one-third of this group (those scoring 6 or less) was the ability to perform simple differentiations. The upper one-third (scoring 10 or higher) was composed predominantly of seniors which contrasts with the situation in the mechanical engineering group. Comparatively speaking, the whole group performed well on most problems, although less than forty per cent were able to solve the four application problems.

The mean score for the *civil engineering group* was 3.6 with only six out of the entire group of sixty-eight scoring 7 or higher. Eleven of the fifteen problems were correctly solved by less than twenty per cent of the individuals, the best performance being on the first problem where it was found that 91% could find dy/dx for $y = x^3 + 3x - 3$. Six of the students who scored 3 or less had a B or better average in calculus. The main engineering background significant in this study was dynamics and strength of materials.

The group of thirty-five *aeronautical engineering* students who took the test made a mean score of 5.9. The highest score was 12 while three scored 0. Only three problems were correctly solved by more than 70% while the one time-rate problem was solved by only 6%. The vast majority of this group had completed seven courses in engineering for which calculus is prerequisite.

There were also thirty-six *architectural engineering* students who took the test—their mean score was 3.2. Only the three simplest differentiation problems were correctly solved by more than half of this group; the second problem, which required ds/dt for $s = 5e^{3t}$, was solved by only 3%. Dynamics was the only engineering course for which calculus is prerequisite that had been completed by this group.

Conclusions

When the test data are analyzed in the light of the ratings made by members of the engineering departments together with the aims implied by the instructional staff in mathematics we seem to be led to the following conclusions relative to the problem of effecting coordination in the teaching of elementary calculus in engineering programs:

(1) The lecture method as presently conceived and utilized is less effective when compared to methods employing more board work and class discussion since the performance of those individuals who were taught by instructors who emphasized the latter techniques excelled.

(2) Engineering students retain command of calculus in direct proportion to the use made of it in subsequent studies —even the superior student otherwise rapidly loses all facility in it during his junior and senior years.

(3) As a corollary to (2), above, the nature of the instructional program in calculus is found to be much less potent than the mathematical content of subsequent courses in engineering in its effect on the retention of facility in the skills learned in calculus.

(4) The "tool subject" approach (in the broad sense previously defined) appears to be efficacious since the students who were taught by mathematics instructors who emphasized this method performed better on the test.

(5) The engineering instructors' appraisals of the relative value of topics in calculus reveal that it would be desirable to differentiate the instructional program in calculus to better adapt it to the needs of different branches of engineering—the electrical and civil engineering groups clearly have divergent objectives beyond the point where fundamental processes have been learned.

(6) Deterioration of the ability to use calculus to the low level indicated in this study indicates that there should be more careful timing of instruction in calculus and the engineering courses for which it is prerequisite—rapid loss of skill sets in early in the junior year unless there is immediate follow-up.

(7) In every engineering group studied there is a wide range of ability to use the skills learned in calculus which indicates that a large number of students are able to succeed in engineering studies on the junior and senior level without having command of the fundamentals—either calculus is not a real prerequisite to these studies or its potentialities are failing of realization due to poor coordination of effort.

(8) This study as well as others closely

related to it shows that much of what is presently taught in the typical calculus course is educational waste as far as the engineering student is concerned—even in groups which performed well on the test there is little evidence of ability to do anything but simple differentiations and integrations and much evidence of serious lack of ability to apply either to the solution of "word problems." We need to concentrate our efforts less in the direction of helping the student to accumulate information and more in the direction of developing his powers of reflection.

(9) The low level of performance of the civil and architectural engineering groups indicates that for some groups eight semester-hours study of calculus is not really prerequisite to success in junior- and senior-level subjects and may merely be serving the purpose of lending prestige to the program of studies or serving as an intellectual screen—both spurious objectives in an educative program.

College Notes

A special program of advanced study for teachers of engineering will be offered by the College of Engineering at **Cornell University** during the university's Summer Session July 2–August 11. The six courses are intended for instructors in mechanics, structures and similar subjects. They will be taught by members of the Cornell engineering staff and will provide opportunity for individual study of particular interest to the student. Courses are as follows: "Elementary Mechanics of Materials from an Advanced Standpoint" and "Applied Elasticity," H. D. Conway, professor of mechanics; "Theory of Elastic Stability," George Winter, head, Department of Structural Engineering; "Plasticity in Engineering," P. P. Bijlaard, associate professor of civil engineering; "Advanced Structural Analysis," G. P. Fisher, associate professor of civil engineering; "Aircraft Structures," Carlo Riparbelli, assistant professor, Graduate School of Aeronautical Engineering.

Ross J. Martin, associate professor of mechanical engineering, has been named associate director of the **University of Illinois** Engineering Experiment Station. He will serve under Dean William L. Everitt, who is also director of the Station, as liaison man between the Station and agencies sponsoring many of its investigations.

William Henry Allison has been named chairman of the civil engineering department at **Clarkson College.** Prior to his recent appointment he was acting chairman of that department.

The appointment of Manson Benedict as professor of chemical engineering at the **Massachusetts Institute of Technology** was announced by Dr. Thomas K. Sherwood, Dean of Engineering at the Massachusetts Institute of Technology. Dr. Benedict, who comes to M.I.T. to expand and strengthen the educational program in nuclear engineering, will join the staff on July 1.

A New Aid in Teaching Kinematics

By MILLARD H. LAJOY
Associate Professor of Mechanical Engineering, University of Minnesota
and
OTIS M. LARSEN
Assistant Professor of Mechanical Engineering, University of Minnesota

Kinematics, as taught in mechanical engineering, has two important objectives. One is to teach the students how best to recognize the relationship between actual machines and their equivalent kinematic or line drawings. The second is to teach methods of displacement, velocity, and acceleration analysis of these machines from the line drawings. The teaching aid to be covered in this paper will deal with the first objective only.

The experience of the authors over a combined teaching period covering approximately twenty years has indicated the need for developing a teaching aid that will help the student visualize the relationship between a line drawing and the actual machine. The use of line drawings alone results in a student's lack of interest, enthusiasm, and willingness to learn. The practice of using models and conducting students on shop tours helps to hold their interest. However, shop tours and models have certain limitations in their use. For example, shop tours usually involve taking a fairly large group through a plant where the student does not have the necessary time available to study the machine operation completely from a kinematic view point. Models are costly to produce if they are to be exact scale reproductions of machines; moreover, many schools do not have the facilities to make them.

The teaching aid about to be described and used by the authors was developed three years ago. Experience gained in using this aid with several thousand engineering students has indicated its usefulness. The value of this aid was further substantiated by working with men from industry through evening extension classes. As a result, the authors feel that it has filled in a gap which has heretofore existed in the teaching of this subject.

The title of this teaching aid is "Kinematic Drawings." By kinematic drawing is meant the reproduction of a line drawing from a pictorial drawing of a mechanism. These pictorial drawings must be selected and carefully prepared so that a minimum amount of written description is necessary to the understanding of how the mechanism works. One of the primary advantages of a pictorial drawing is that one usually can visualize how the mechanism works from the drawing alone. The use of a photograph or an orthographic drawing often requires an acompanying written description to explain the operation of the mechanism involved. It is then necessary to alternately refer to written description and drawings which are sometimes tedious and time consuming. It could well be one of the reasons for a student's lack of enthusiasm and interest in the course.

To further explain the use of kinematic drawings, Figs. 1 and 2 have been included as typical examples. Below each pictorial drawing a solution is indicated only for the position shown.

Figure 1 shows a horizontal handle

clamp. This is a very common mechanism used in jig and fixture work and new to most students. The individual links of a four-bar mechanism are immediately obvious. The pin joints or bearings are clearly evident. In addition, the student sees the value of extending certain links of a four-bar mechanism to serve a useful purpose. For example, note how the left crank is extended in the form of a bell crank. The slotted opening on the extension is for the clamping stud. Also, the connecting link is extended to provide a pressure pad and additional leverage to operate the clamp. The student is required to construct a line

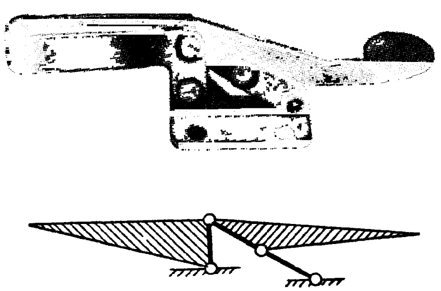


FIG. 1

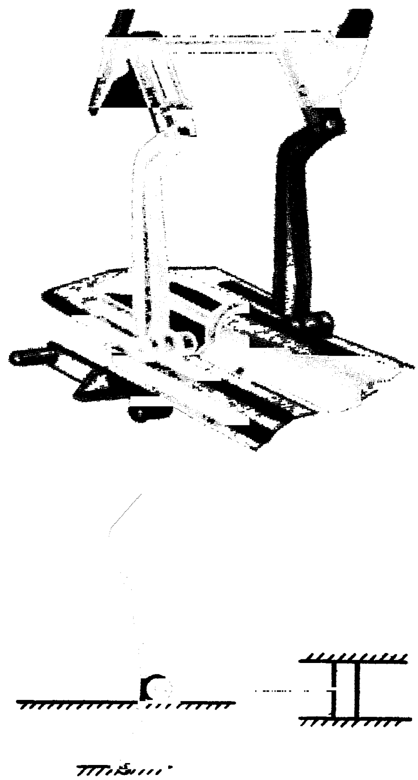


FIG. 2

drawing of the basic four-bar mechanism, as commonly used in kinematics. He may be required to make several kinematic drawings from this picture, such as the mid-open and full-open positions. These drawings should be made on a proportional scale basis.

Figure 2 shows the pictorial drawing of a hydraulic truck lift. This is a very practical and simple mechanism hydraulically operated. A student studying this drawing for a reasonable length of time will soon see that the hydraulic force is transmitted through a roller to a cam surface. The truck platform or box is omitted from the drawing purposely. This creates a problem for additional thinking on the part of the student. He may also be required to make a kinematic drawing of how the truck box is pivoted and raised for unloading.

In solving such problems from the pictorial drawing, the student automatically sees practical applications of the basic four-bar mechanism. Furthermore, when he sees these mechanisms in industry, he will recognize them without difficulty.

The use of the teaching aid, which we have entitled "Kinematic Drawings," has greatly improved the quality of teaching in kinematics. The instructors are able to present problems more clearly and effectively. Students show more interest and enthusiasm. If this aid is used to its fullest extent, we are confident that students will complete their course in kinematics with a better knowledge of how machinery works. Thus, when he sees machinery in operation, he will be better prepared to visualize the functions of the mechanisms involved.

Significance of Courses in Statistics for Engineering Students

By MASON E. WESCOTT
Assistant Professor of Mathematics, Northwestern University

Introduction

This paper will present three points in support of the contention that engineers should have some training in statistics. These points are by no means mutually exclusive, much less exhaustive, and their order of presentation implies no intention to rank them in order of importance. Where courses in engineering statistics should be offered will also be considered.

The Engineer and the Statistical Concept of Variation

Engineers are, of course, *aware* of variation, witness such things as the specification of tolerances (however arbitrary they may be) on blue-print drawings, "safety factors," and the frequent occurrence of probable error statements in connection with engineering calculations. But the typical engineer is all too often inclined to think in terms of *averages,* accepting *dispersion* as a sort of necessary evil that has to be endured as best one can. He is seldom adequately exposed in his formal training to the fundamental fact that all observed data involve the element of random error, much less to a consideration of the possibility that a proper understanding of the laws that govern this element can become a powerful asset to him in his treatment of engineering data.

The engineer untutored in statistics is prone to rate, for example, a battery of filling machines as essentially equivalent in performance if their *average* deliveries are comparable, neglecting the possibility that one of them may be four times as variable as the most stable machine in the battery. Moreover, he is most likely entirely ignorant of the fact that each machine will have a natural tolerance of its own even when operated under optimum conditions.

It has been the writer's experience in teaching statistics to engineers both on and off the college campus that they find the statistical concept of variation in observed data an entirely new and revealing way to look at their problems. Such simple things as the frequency distribution, the standard deviation as a yardstick for measuring variability, the concept of sample vs. universe, mathematical models for idealizing variation patterns such as the Gaussian, Bernoulli, and Poisson models, operating characteristics for picturing the discriminatory powers of acceptance sampling plans, and elementary significance tests such as the Shewhart control charts for distinguishing non-random from random variation give the engineer not only better, sharper tools with which to attack his problems but also a wholly new viewpoint toward them, viz., the *statistical* viewpoint.

Looked at from this viewpoint, the engineer can with confidence shift his concern away from the futile objective of exactness to the more realistic objective of statistical stability. Thus the engineer needs to learn that variation is the one great dominating law of nature so that he can begin to look at his prob-

lems and handle his data within the framework of appropriate statistical laws. These laws do not *replace* the physical laws he learns in his formal engineering training: the laws of statistical variation simply extend and reinforce almost everything he has already learned by translating this knowledge in terms of the concrete reality of observed data. He no longer need *fear* variation, but rather to accept and respect it as an inevitable factor that must and can be taken into account on just as scientific a basis as any other factor in the problem.

The concept of statistical variation in observed data, an acquaintance with the laws it obeys, and an appreciation of its prevalence and importance in all areas of engineering activity together provide the most important reasons why an engineer should study statistics. Without this point of view and a working knowledge of at least the basic statistical techniques that implement it, there is no question but that a man can become a *good* engineer; with it he will be a *better* engineer. He will then be concerned not only with *accuracy,* but also with *precision,* not only with *averages,* but also with *dispersion,* and, what is more, he will understand *both* these concepts much more intelligently. He will be able to make predictions and action decisions based on observed data in the light of defensible probability statements, which is a much-to-be-desired attainment and something that is totally impossible without the support of appropriate statistical techniques.

In short, until an engineer understands the inevitable presence and proper treatment of statistical variation in his design problems, his raw material, his fabricating processes, his testing procedures, his measurements, and the analysis of his observed data he is in somewhat the same spot as the one-armed paper hanger who eventually gets the room papered but with a lot more effort, uncertainty, and expense than would be required if he had two arms available.

The Engineer and the Statistical Concept of Data

The engineer must of necessity deal continually with observed data. The observations of interest to the engineer are generally made for the purpose of investigating postulated relationships among variables, discovering new relationships, or to serve as a basis for making action decisions.

For example, *how* are the physical properties of a given steel related to the relative proportions of ingredients put into the melts and the extent to which process practices are modified?

How is the yield of a given chemical process related to temperature, humidity, chemical analyses of ingredients, and other more or less controllable factors?

If variable B *is* related to variable A, within what limits must A be controlled to insure the delivery of B within desired limits?

Is this new method *really* better than the old method?

Can this process actually meet specs?

Should we accept or reject this lot of material that has been presented for inspection?

If we can control components A, B, C within predictable limits, within what limits can we expect to control the assembly $A + B + C$?

Conversely, *if* the assembly $A + B + C$ must meet a specified tolerance, what are realistic tolerances for the components A, B, C?

What is the optimum re-set cycle for this grinding operation?

Are the analyses of laboratory A and laboratory B mutually consistent on the samples sent them, and if not *what* alternatives have we?

Data gathered to shed light on these and many similar problems represent typical engineering data. They also represent typical *statistical* data whose collection, analysis, and interpretation may range all the way from the trivial to a point beyond the frontiers of existing techniques to handle. It is imperative to

know how to extract from such data all the valid information there is in them and also how to *avoid* getting from the data interpretations that are *not* justified. It is imperative to recognize that interpreting data arising from repetitive operations, or operations that *can be conceived* of as repetitive, always involves two fundamental risks:

(1) the risk of falsely rejecting an assumption that is, in fact, correct, and
(2) the risk of falsely accepting an assumption that is, in fact, incorrect.

Furthermore, *all* data are expensive, so one buys as little as possible. On the other hand, generally speaking, the more data one has, the more valid are conclusions based on correct evaluation of these data.

How does one strike an economic balance between the *amount* of data and the *cost* of data?

How does one wring from such data as can be secured the maximum of dependable information?

How does one arrange matters to *get* data from which he can sort out the various component factors that contribute to the elements of identifiable variation and random error in a repetitive operation, be it a laboratory experiment, a pilot run, a manufacturing process, or a research project?

How does one make valid comparisons among these components so that he can state on a probability basis his degree of assurance as to their relative importance?

These, and many other pertinent questions, are questions an engineer must face sooner or later. When they arise, they are questions that *must* be answered *anyway* and *someway;* they can be answered *much more intelligently and economically* with the help of appropriate statistical techniques than without such help.

It follows inevitably that a *good* engineer will certainly be a *better* engineer if he has acquired the statistical viewpoint toward the fundamental importance of good data, collected in adequate amounts from the right sources in terms of planned objectives and subjected to the revealing analysis of appropriate statistical techniques. In short, the engineer cannot avoid the necessity of relying on data. Data cost money. The only *sure way* to get the most out of data for the money and effort put into getting it is through the application of modern statistical tools. This, then, is a second compelling reason why engineers should study statistics.

The Engineer and the Industrial Picture

American industry, which is by all odds the heaviest consumer of engineering graduates, is becoming increasingly "statistics-conscious." It is virtually certain that this trend will increase rather than diminish in the foreseeable future.

During World War II, statistical procedures and statistical thinking were successfully injected into wide segments of American industry where they had never been heard of before. Since 1945 there has been a steady advance in the successful application of statistics all along the industrial front. In the mechanical, electrical, chemical, metallurgical, food-processing, textile, and many other fields overwhelming evidence is available to attest the value to industry of properly applied statistical techniques. In the field of statistical quality control alone there is an almost feverish activity to get existing personnel trained in the principles and practice of this new management tool.

As an inevitable consequence, industry is going to ask the engineering applicants it interviews "How many credit hours in engineering statistics have you had?" And it is going to give preference to the man who can present evidence of such training. This sort of preferential interest in the engineering student who has had training in statistics is *already happening,* but pressure in this direction has really *just begun.*

When American industry decides it will buy a new tool, as it is rapidly deciding it wants engineers with training in statistics, it calls for delivery right now, and in carload lots! As of today, the engineering colleges in this country simply are not meeting adequately the challenge their best market for engineering graduates is beginning to throw at them. Courses in statistics designed specifically for engineering students must be provided because the demand for engineers with such training cannot be ignored much longer.

Moral: engineers should study statistics because such training will open the door to better jobs for them.

Where Should Courses in Engineering Statistics be Given?

In the undergraduate program, the ideal spot is toward the end of the junior year or the beginning of the senior year. By this time the student has begun to acquire a maturity and background against which the instruction in statistics can be made operationally meaningful. At this level the introduction to statistics sheds much light on what the student has already experienced in his previous engineering courses and prepares him to take fuller advantage of the course work remaining.

Undergraduate courses in statistics are already an integral part of most programs leading to a degree in Industrial Engineering. As a starter such courses could be offered as electives to students in programs leading to other degrees in engineering. Eventually, however, engineering colleges must face up to the necessity of providing at least a general, introductory course in statistics for engineers and the desirability of placing this course on the required list in all engineering programs.

At the graduate level, there should be provided as a prerequisite to candidacy for a degree a course in statistics emphasizing the philosophy and basic techniques of experimental design and related topics as they apply to the treatment of engineering data. Admittedly this is an ideal not generally attainable in the very near future in many engineering schools because of the lack of qualified personnel to teach such a course if for no other reason. It is, nevertheless, a worthy ideal whose attainment would contribute substantially to more effective research in graduate programs. Something like this will ultimately be achieved by those engineering schools that offer graduate work and do not as yet have courses in statistics at this level.

Finally, engineering schools can render a very genuine service to the industrial communities they serve by making available on a part-time basis, or through the medium of short, intensive training sessions, a series of down-to-earth, practical courses in engineering statistics for men already in the field. A number of engineering colleges all over the country are already doing just this with notable success.

These courses generally go under the name of "statistical quality control," but they are nevertheless essentially courses in engineering statistics. Their conspicuous and sustained success in nurturing the statistical viewpoint among engineering personnel, often long since graduated from formal college classes, could and should provide engineering college administrators with a wealth of illuminating clues both as to the value of statistics for engineers and as to the course content and the nature of the instruction best suited to engineering needs.

Courses in Statistics for Engineering Students

What and How Statistics Should be Taught to Engineering Students

By IRVING W. BURR
Professor of Mathematics, Purdue University

A. *How to Teach Statistics to the Engineering Student*

Although there is a growing tendency to use the statistical approach in engineering and science courses throughout the curriculum, this movement is just at its beginning as compared with what we may expect in the future. With due consideration to space it seems best to avoid discussion of this broad problem and to limit ourselves to statistics courses as such.

Theory vs. Applications

Because of the crowded nature of our engineering curricula, we must of necessity use the scalpel on what we would like to have the student carry away from the course. Commonly a single statistics course is all that the engineer can take. We therefore must choose a proper balance between the applicational and the theoretical aspects of the subject matter. Since we cannot do full justice to both, I *believe the emphasis should* be on the former rather than the latter. We should certainly aim at seeing that for each technique the student knows clearly what it is, how to use it, how to interpret it and what its limitations are. Then in, and around this, we can give him as much derivation and mathematical justification as we can. The importance of good, live, up-to-date applications can hardly be overemphasized. Engineers are mostly intensely practical people and they like to see how the methods can be counted upon to help them in their own future (and present) work. Applications, especially if out of the instructor's own experience, have great value in motivation. Selling the student on the importance of the subject matter, whether done consciously or unconsciously, is an integral part of the successful statistics course.

Use of Demonstrations

Often times as a supplement to derivations or as a substitute, demonstrations can be very effective. With dice, numbered chips, beads, etc. we can illustrate innumerable statistical situations. Such demonstrations as control charts in control and then with assignable causes introduced, sampling from a stratified situation, the approach of sample mean distribution toward normality, sample vs. population, significance of differences, analysis of variance, acceptance sampling with attributes and variables, sequential analysis, and samples of correlation data, *can all be of much interest* to the instructor as well as the student. In the strict sense such demonstrations are not a substitute for mathematical derivations, but (a) they do motivate the student and illuminate certain aspects of statistics, and (b) the student can use such demonstrations to help teach and sell others, who have little mathematical background. It is possible moreover to use division of labor, each student drawing several samples, and thereby to learn something about such unsolved problems as the sam-

pling distribution of ranges and standard deviations from skewed populations. Finally we may say that the more avenues we use to instruct and convince the student, the better.

How Many Courses?

Being in the fortunate position of being able to require mathematics through the calculus as a prerequisite, much can be accomplished in a one-semester course. Most junior or senior engineering students, however, are handicapped by a lack of industrial experience. Accordingly many of them have difficulty in understanding the practical implications of the subject matter. The writer believes that for a one or even a two-semester program, the main emphasis should be on applications. On the other hand, if the student can take four courses, perhaps as an undergraduate and graduate, then two applicational courses taken in conjunction with two courses in theoretical statistics provide an excellent background.

Calculation

Some attention should certainly be given to the matter of calculation. Having known only the slide-rule and logarithms, most engineering students derive much pleasure out of learning what a modern calculating machine can do in cumulating answers and in combination problems. The importance of efficient calculational technique may be emphasized by saying that a statistical technique *is often practical* or *not depending solely* upon how long it takes to calculate the results. When one considers that inefficient computation may take twenty times as long as proper methods, it is obvious that some attention should be paid this subject.

The Statistical Attack

If toward the end of his course the student still thinks of statistics as a bunch of rather isolated and unrelated techniques, the course can hardly be called a success for him. He should have begun to sense the essential unity of statistical technique. He should have seen that statistics is largely concerned with the measurement and control of random variation, and should be able to recognize the statistical aspects of practical engineering problems and research.

We can encourage this (a) by fresh problems that do not relate only to immediately preceding subject matter, (b) by problems which point forward and give the student opportunity to develop some of the succeeding technique, (c) by giving some problems with little or no instructions, letting the student choose the attack, (d) by reading in class letters from off-campus asking statistical questions, (e) by giving some of the background of problems and showing the fumbling which was done before it became obvious that there was a statistical tool available, (f) by discussion in class of the different ways in which industrial and research organizations have planned for statistics, (g) by suggested readings of articles by industrial men on how they got started, and what applications they have made, and (h) by field trips and having industrial men in to speak.

The Instructor

For most effective presentation the instructor should be a mathematical statistician with much industrial background and acquaintance with engineers, or an engineer with a broad technical background and much theoretical and practical statistics. Neither category of people *is exactly a glut on the market.*

B. *What Statistics to Teach the Engineering Student*

There is at present an almost unlimited menu from which to choose topics for, say, a two-semester course in statistics. The following outline is presented as fundamental statistical material, all of which an engineer is likely to find useful if he goes very far in statistical applications. They are listed in very roughly the order in which they might be presented. The outline obviously cannot be

covered if we try to do a complete job of the mathematical statistics in addition to applications, demonstrations and calculational methods. It seems best to me to place more emphasis on the application of the methods than on the theory, in order to cover as much ground as possible.

Outline of Topics

1. Frequency tabulation and graphs.
   Including the cumulative frequency table. Basic tools, which are sufficient to solve some practical problems alone.
2. Arithmetic mean, range, standard deviation.
   Bringing in the concepts of average and variability. Calculations with raw and frequency data. Scarcely more than a definition of median, mode and average deviation.
3. Concept of sample vs. population.
   Some theory and experiments to illustrate the principles in action.
4. Moments.
   Efficient calculation, interpretation, omit "platykurtic," etc.
5. The normal curve.
   As the basic or first approximation, theoretical frequency curve.
6. Control charts for measurements.
   a. Averages (A.M.) and range
   b. Standard deviations
   c. Many applications
   d. Special topics like varying sample sizes, per cent out of specifications, ways of taking samples, tool wear, modified control limits, stratified data, large sample sizes.
7. Other frequency distributions and probability.
   Emphasis on the Pearson type III. Simple probability leading to hypergeometric, binomial and Poisson. Use of table and recursion calculation, approximations.
8. Control charts for attributes.
   Charts for fraction defective and number of defectives and of defects.
9. Acceptance sampling for attributes.
   Principal emphasis on Joint Army-Navy tables, but also some material on Army Ordnance and Dodge-Romig. Emphasis on the operating characteristic curve and other ways of analyzing a sampling plan.
10. Linear correlation.
    Ungrouped and grouped data. Mostly fitting by least squares. Efficient calculation.
11. Sample vs. population.
    For tests on mean and standard deviation, attributes, correlation coefficients. Confidence limits.
12. Significance of differences.
    The same statistics as in 11, and also average ranges for comparison of control chart variabilities. Technique using differences of paired items.
13. Analysis of variance.
    Simple designs through Greco-Latin squares and factorial designs, with and without replication. Relation to control charts. Bartlett's test for variabilities. Tests for existence of correlation and linearity.
14. Chi-square test.
    Goodness of fit, contingency tables.
15. Design of experiments.
    Emphasis on importance of design. Plan vs. "Here is some data. What can I do with it?"
16. Statistics of combinations.
    Sums, differences, some work on products and quotients. Errors in computations.
17. Acceptance sampling for measurements.
    Use of control charts. Single sampling to match two points on the operating characteristic curve. Reduction of sampling.
18. Sequential analysis.
    Attributes and measurements (averages, two cases, and variability).
19. Curve-fitting.
    Least squares, transformations to linearize, selected points for otherwise too difficult problems, goodness of fit, arbitrariness of curve-fitting.
20. Multiple correlation.
    Theory and use of simplified calculations. Significance tests.
21. Analysis of covariance.
    Several cases, a good opportunity to review analysis of variance.
22. Other correlation methods.
    Biserial and tetrachoric correlation, reliability, effect of range of data upon correlation coefficient.
23. "What does it all mean?"
    Comparison, unification and review of material.

The foregoing is a list of what an engineer can use if in a position involving many statistical problems. Any or all of the techniques can easily prove useful to a practicing engineer. Naturally they are not all of equal expectation of use to any one engineer nor any group, so some selection, different order or emphasis is only to be expected. It is possible to include material on about the first ten topics in a one-semester course. The whole outline probably includes too much for two semesters, but does give an idea as to the desirable statistical background. Adequate references should be given for further study by the students.

College Notes

David L. Arm, Dean of the School of Engineering at the **University of Delaware**, has been granted a leave of absence for one year to participate in an educational program sponsored by E. I. duPont de Nemours and Company, Inc. Dean Arm is the first of a number of engineering school administrative officers who will be invited to participate in this program. These engineering college officials will be given an opportunity to study, from a top management viewpoint, the operation of the engineering department of this corporation. The duration of the program is one year, and the participants will be assigned for varying periods of time to the different divisions of the engineering department where they will have an opportunity to study not only the relationship of the divisions of the engineering department to each other, but the relationship of the engineering department to the activities of the company as a whole. They will inspect various operating plants and will visit some of the new construction activities of the company. The duPont Company is establishing this program to provide a closer liaison between engineering activities in industry and engineering educational programs in the colleges.

Graduate students and faculty members from five California universities and engineers from San Francisco Bay Area firms will meet at Stanford this summer for the fourth annual **Heat Transfer and Fluid Mechanics Institute.** Professor A. L. London of Stanford's department of mechanical engineering announced today that serveral hundred scientists would meet June 20–22 to keep in touch with the latest advances in the fields of heat transfer, fluid mechanics, and related subjects.

The appointment of Dr. Charles Stark Draper as Head of the Department of Aeronautical Engineering at the **Massachusetts Institute of Technology** was announced by Dr. James R. Killian, Jr., President of the Institute. Dr. Draper, professor of aeronautical engineering, has been deputy head of the department as well as director of the Instrumentation Laboratory, which he will continue to administer for the time being.

A Survey of Faculty Teaching Loads in Chemical Engineering

By MELBOURNE L. JACKSON

Assistant Professor of Chemical Engineering, University of Colorado

The colleges and universities of the United States have recently passed through a period of peak enrollments following the war. Almost all engineering divisions have undergone rapid expansion with great enlargement of teaching staffs. This is an opportune time for a re-examination of teaching duties. As teaching loads become less, it might be expected that more time would be allowed for such professional pursuits as research, writing and active participation in the chosen field. An examination of teaching loads would form the starting point for such an evaluation, and for this purpose a survey of present and desirable practice was made. Although the results apply specifically to the field of chemical engineering, they may be of interest to other branches of engineering.

It is readily apparent that a teaching load depends on many things. Several attempts have been made to relate all the factors involved by a formula but most institutions prefer not to follow such a formal procedure. It was thought that the actual course load being carried by teaching staffs in the various schools at a given time would serve as a basis of comparison. The questionnaire submitted was short and asked ten questions, each of which could be answered by a number. Assurance was made that the identity of the various schools would remain confidential. The questionnaire requested information as of Spring, 1950 and is reproduced below:

Teaching loads per full-time staff members:

- Actual credit hours ....
- Actual contact hours per week ....
- Desirable number of credit hours ......
- Allowance for laboratory supervision (credit hours per contact hour) ......
- Allowance for graduate thesis supervision (credit hours per student) ......

Chemical engineering students and teaching staff:

- Number of undergraduate Juniors ......
- Number of undergraduate Seniors ......
- Number of graduate students ....
- Number of full-time faculty ....
- Number of part-time faculty ....

One hundred six schools were circularized and it is believed that this comprised all the institutions in the United States which offer a curriculum in chemical engineering. It included the 60 accredited schools and the 92 institutions having student chapters of the American Institute of Chemical Engineers as published in the 1950 Year Book of this society.

A total of 86 replies were received, or 81% of the questionnaires submitted. Of these, 83% of the accredited institutions responded and 78% of the non-accredited. Also, 80% of those schools having student chapters replied. In all but a few cases the reply card was signed by the head of the department. The results of the survey may therefore be considered as reliable and significant.

The average results are given in Table I. Ten of the accredited schools answered the first question as actual teach-

TABLE I

SUMMARIZED REPLIES TO QUESTIONNAIRE ON TEACHING LOADS

Actual Credit Hours	Desirable Credit Hours	Contact Hours	Credit Hours per Laboratory Hour	Credit Hours per Graduate Student	Students per Full-Time Staff	Students per Full- Plus Part-Time Staff
Accredited Institutions						
Including allowance for thesis supervision:						
11.3	10.8	14.8	0.54	1.0	22.8	18.1
Excluding allowance for thesis supervision:						
7.2	7.0					
Non-accredited Institutions						
10.6	10.3	14.7	0.48	1.0	16.0	14.9
All Institutions						
10.9*	10.6*	14.7	0.51	1.0	20.0	16.8
Minimum						
7.5*	7.0*	9.0	0.33	0	6.8	5.4
Maximum						
18.0	16.0	30.0	1.0	3.0	78.4	56.3

* Excludes those replies giving teaching loads without an allowance for graduate thesis supervision.

ing hours excluding allowance for graduate thesis supervision. The results for this group are therefore reported separately. The last two columns represent an attempt to evaluate the ratio of number of students to number of teaching staff. This was done in an arbitrary manner, both with respect to the staff and students. The total number of students was taken as the sum of the junior and senior, and graduate students. This was considered justifiable since the major teaching load falls within these groups.

TABLE II

DISTRIBUTIONS OF TEACHING LOADS

	Actual Credit Hours	Desirable Credit Hours*
Under 8	15%	15%
8–10	30	42
11–13	41	36
14–17	13	7
Over 17	1	0
	100%	100%

* Excludes those replies giving teaching loads without allowance for graduate thesis supervision.

It does not include any accounting for those courses taught in chemical engineering departments as service courses for other departments. Also, it excludes sophomore students who ordinarily take few, if any, chemical engineering courses during this year. Two values are given: one as the ratio of students to full-time staff only, and the other as the ratio of students to full-time plus part-time staff. For the latter purpose a part-time staff member was considered to carry one-third of a full load. The distributions of some of the data are given in Tables II and III.

TABLE III

DISTRIBUTIONS OF STUDENT-STAFF RATIOS

	Students per Full-Time Staff Member	Students per Full- and Part-Time Staff Member
Under 10	9%	13%
10–14	27	32
15–19	31	36
20–29	21	12
Over 30	12	7
	100%	100%

There is no significant difference in the replies of accredited and non-accredited institutions except in the case of the student to teacher ratio. Some accredited schools had very large ratios. The number of actual and desirable credit hours of teaching load are very nearly the same. Eighty-five % reported desirable loads of 12 credit hours or less, and 55% of 10 or less. For actual contact hours 87% gave 20 or less per week, and 62% as 15 or less.

In making allowance for laboratory instruction, values of ⅓, ½, and ⅔ credit hours per laboratory hour were common with 72% reporting ½ or less. The question of allowance for graduate thesis supervision received the most varied and inconsistent answers. Seventy-one schools reported having one or more graduate students but only 42 gave any consideration for thesis supervision on teaching load. Ten reported that no allowance at all was made and a number either left the question blank or made comments by way of explanation. Most of the latter were schools having only a very few graduate students and most were not accredited. Based on the 42 schools actually reporting an allowance, the value would be 1.4 credit hours per student.

Comments were invited and a number were received. Some of these will be passed along because they were made by leading educators and may indicate a trend of thought.

It was one man's ". . . theory that loads are always too high and it is desirable to get them as low as you can." Another ". . . allowances are made for the first time a course is taught, the number of different sections of the same course, hard or easy courses, graduate or undergraduate courses." Concerning graduate thesis allowance, ". . . some schools are very much inclined to dodge the issue," and another, ". . . allowance for graduate thesis supervision is so variable that we have no standard allowance." Others, ". . . extra allowance is given for graduate courses and evening classes," ". . . a maximum of three courses at any one time is permitted," ". . . a man doing little or no research carries a heavier teaching load," ". . . help the staff do a better job by giving them clerical and grading assistance," ". . . try to balance job time in considering laboratory and graduate thesis allowances."

And perhaps by way of conclusion: "It is a known fact that graduate work in an engineering school tends to improve the quality of undergraduate teaching, that research is necessary in order that there may be a graduate school of high quality," and "You cannot overload a teacher. He has just so much physical strength, so much mental strength and so much mastery of his subject matter field. He just spreads himself thinner. He does meet his classes but he does not use as much preparation time, he does not use as much grading time."

It is hoped that this survey will encourage a re-examination of present teaching loads and duties with a view to offering additional incentives to the profession of teaching by allowing more time for course preparation and appraisal, research, writing and consulting.

College Notes

The recently completed Alumni Scientific Laboratories Building at **Drexel Institute of Technology** more than doubles the space for engineering by adding over 45,000 feet of floor space. The additional space is required for engineering because of the further development of Drexel's undergraduate curricula, addition of graduate studies leading to the Master of Science degree, and the addition of a program leading to the Bachelor of Science degree in the Evening School.

Style in Engineering Writing

By EARL S. LAMM

Assistant Professor of General Engineering, Purdue University

Most engineering students object to taking a course in engineering writing because they feel that skill in expressing themselves is not necessary for success in their chosen field. Many students who have had some previous experience in industry say that they *know* that writing courses are useless because throughout their experience they have never had to write a report which amounted to more than a form to be filled out. To bolster their argument they say that a successful engineer should be able to confine himself to engineering work and should have a secretary to write his reports for him.

However it usually takes some time before the graduating engineer arrives at a position which warrants a secretary. Even after he has had a full time secretary assigned to him he will be unpleasantly surprised to find that he still must compose the greater part of his reports himself. Throughout his introductory period in industry his ability will be judged by the type of reports he can turn out by himself. True, in most starting jobs an engineer will not have to write detailed reports or long technical articles. But as he advances in his profession he frequently finds that his time is taken up more and more by administrative duties and that one of his chief responsibilities is to describe his work and that of his section or department clearly, concisely, and logically: a task for which his report writing classes in school should have prepared him. It is safe to say that a majority of engineering graduates find themselves handicapped at this stage in their career owing to their lack of skill in expressing themselves.

The fact that "clarity," "conciseness," and "logicality" in writing can not be defined accurately, together with the fact that in any given piece of writing it is almost impossible to point out just why these characteristics do or do not exist, makes it particularly hard for the student to judge the usefulness of practice writing designed to help him attain these standards. Nevertheless the clearer, more concise, and more logical, a piece of engineering writing is, the better it serves its purpose. The writer's *style* is an important factor in helping to achieve these ends.

The engineer should realize that there is no such thing as "good writing" irrespective of the audience for which the writing is intended. What may be good writing from the point of view of one audience may be unintelligible to another. For example an engineer may be required to stop work on his research report to contribute a section on the work under his direction for a personnel department pamphlet entitled "What Your Company Means to You." Obviously he must make his style more informal, consider the use of some slang for effectiveness, and hold himself back when he feels like using "big" words.

Classification of Styles

Every writer's style differs, but general styles of writing may be classified as follows according to the expressions that are used: vulgar, dialectal, slangy, colloquial, formal, literary. This classification is by no means absolute: the same expression may be formal on one occasion, colloquial on another, and lit-

erary on a third. For example many persons entering the Armed Forces in recent years found that language which was considered vulgar in their previous environment had colloquial status in their new surroundings.

Language is vulgar if it is objectionable to those people who have a reasonable amount of sensitivity about coarseness of expression. Owing in great part to our best-selling novels, the class of vulgar words is fast diminishing. Whether or not a word could be spoken in front of ladies used to be a good test for its vulgarity. This test is no longer reliable however.

Colloquial language on the other hand is perfectly acceptable in ordinary conversation. Even authors who write in the most literary style usually speak less formally than they write. This spoken language is described as colloquial. Colloquialisms are those parts of colloquial language which are least formal. For example in saying, "I could see in a jiffy what was wrong with the way he bossed the job," the expressions "in a jiffy" and "bossed" are colloquialisms. Colloquialisms are proper in, and often add color to everyday speech, but they are undesirable in conventional engineering writing because their precise meaning is sometimes not widely known, owing in part to the range of emotional connotations which they may hold for the separate elements of the audience. An engineering report should be written in words whose meaning is clear and definite to all those to whom it is addressed.

Dialectal writing is also unsuitable in engineering reports for a similar reason: a dialect is defined as a regional way of speaking which differs from the accepted standard for the country as a whole,. Reports written in dialect may be the acmes of clarity for those members of the audience who are at home in the particular dialect, but they lack precise understandability for the rest.

Odd and tricky expressions which are in vogue but which are not authorized by the dictionaries and other standards of correct usage are called slang. An advantage of slang is that it is frequently more forceful and often expresses an idea in fewer words than colloquial or formal language. It is a useful device for attracting attention and is therefore often found in advertising copy. The fact that it carries many strong connotations makes it adaptable to humorous writing. However slang should not be used in conventional engineering writing because it is frequently short-lived and its inclusion would limit the writing's period of usefulness. Furthermore slang expressions are likely to express different meanings to various sections of the audience.

Literary Style For Engineers

Instructors in engineering writing who deprecate vulgarisms, colloquialisms, dialect, and slang, often unintentionally send their students searching for big and high-sounding words with the result that the students attempt a highly literary style instead of a more serviceable formal style. Both formal and literary styles are acceptable from the lexicographer's point of view. Their advantages over less formal styles is that the style itself causes a minimum of distraction from the contents of the writing. The concomitant disadvantage is that the writing must rely almost entirely on its content for interest.

The main difference between formal and literary styles of writing lies in the choice of words. Most of the words in English are derived from either one of two sources: Anglo-Saxon (abbreviated AS.) and Latin (abbreviated L.). For most people the Anglo-Saxon root words are the better understood, mainly because they are more likely to have familiar associations. Latin root words were first introduced into English as a result of the Norman conquests, and for a long time their use was restricted to the governing classes. Ever since, there has been a continual addition of Latin root words to English, sponsored primarily by intellectual and literary leaders who

desired a vocabulary unencumbered by the precise, and therefore often coarse, meanings which the Anglo-Saxon root words had developed. For example, in a dispute among intellectual schools of thought it was probably safer to call an opponent a prevaricator (L. root) than to call him a liar (AS. root). At the highest levels of intellectual feudery the word "terminologicalinexactitudinarian" (L. root) might be used.

Today the writer frequently has a choice between a Latin root word and a synonymous Anglo-Saxon root word. The Anglo-Saxon root word usually has wider audience acceptance while Latin root words are particularly serviceable as classification words because they are freer of concrete associations. For example, the word "protuberance" (L. root) is a good classification word. *What is a protuberance? Compare it to the* Anglo-Saxon root word "bump." Everyone knows what a bump is—it's a bump—a special kind of thing that sticks out. On the other hand a protuberance may be a bump; it may be a stud; or the end of a rod; or a person's nose; i.e., any element of the class of things that stick out.

While the engineer usually needs to be clear and explicit, and, therefore, often prefers the Anglo-Saxon root words, the fact that Latin root words usually are more general in meaning makes them useful to him when he wants to present some fact less forcefully. Just as a "refined" author will use "perspiration" (L. root) instead of "sweat" (AS. root), so an engineer reporting on a company's operations might use "decline in activity" (L. root) instead of "slump" (AS. root), and "misappropriation" (L. root) instead of "stealing" (AS. root). This technique is effective not only because the Latin root word carries a less precise meaning, but also because frequently it includes conditions which do not come under the derogatory meaning of the word at all. For example, if an employee was "fired" (AS. root) there is no question about what happened; however if his "services were dispensed with" (L. root), a loose interpretation would leave room for his not having been replaced after he voluntarily left.

The style of writing which abounds in Latin root words to the exclusion of simpler Anglo-Saxon root synonyms, and which in general seems to prefer the big word to the small word, is called literary. This style is alright for philosophers and social scientists, whose main stock in trade consists of concepts and classifications. Since philosophers actually do know more about transcendentalism (L. root) and anthropomorphism (L. root) than they know about God (AS. root) the literary style serves them to good purpose. However the engineer is usually trying to express something concrete and therefore the style which he should choose is the formal style. *This style is free from vulgarisms,* colloquialisms, dialect, and slang; it is also free from big words where a simpler word will do. It uses neither the short cuts characteristic of the less formal styles nor the overelaborate constructions of the literary style. Though it lacks emotional appeal it is clear, concise, and logical.

Here is an example of similar ideas expressed in some of the different styles compared above:

(a) formal style:

"The engineer should be aware of the applications of the scientific method to fields other than his own. For example, he should understand the basic principles of industrial psychology which result from the scientific study of human relations, because if he is successful he will spend a surprisingly large part of his time in simply dealing with people."

(b) literary style:

"A member of the engineering profession should be cognizant of the utilization of the methods based on the systematic classification of knowledge in realms which are exclusive of his major field of preoccupation. Focusing our attention on only one phase, we see that he must

necessarily be well grounded in the basic psychological end-products of the dynamics of the exploration and classification of anthropological relationships which fall within the range of industrial usefulness, since, as a responsible member of his profession, he will be required to spend an astonishingly large proportion of his time in interaction with other members of various social units.

(c) combination slangy and colloquial style:

"A slip-stick artist's gotta savvy how the brainpower's being worked in other rackets. Fer instance he's gotta know the up-to-date ways of digging other people on the job, because if he's a B.T.O.,* he's tripping over folks all the time."

* Big-time operator.

Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Thursday, March 15, 1951, at Evanston, Illinois. Those present were: F. M. Dawson, *President,* H. H. Armsby, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, and M. Wiltberger.

Report of the Secretary

The Secretary reported that the application of the Society for registration as a non-profit corporation in the State of Illinois had been tentatively accepted, pending the submission of certain official documents requested by the State. He also reported that the Westinghouse Educational Foundation had agreed to continue the George Westinghouse Award for another period of five years. Announcements and nomination forms for the Award have been sent to deans of engineering colleges and an announcement was published in the January issue of the Journal.

Report of the Treasurer

The financial report of the ASEE as of February 28, 1951 was presented, together with a comparative statement for preceding years. The Treasurer reported that the income and expense for the year will probably be close to the amounts budgeted in the 1950–51 budget. Certain changes in accounting procedure with respect to the Special Projects Fund were recommended.

The tentative budget for 1951–52 was considered. Final action on this budget will be taken at the June meeting.

The Treasurer also reported that orders had been placed for two bronze replicas of the Lamme Medal and one gold medal in order to be certain of delivery before material allocations take place.

Report of the Vice Presidents

Vice President Armsby reported that a Clearing House Bulletin had been prepared during the year to provide for an exchange of information among officers of Sections and Branches. This was intended to assist Section officers in planning their meetings.

Vice President Armsby called attention of the Board to the appointment of a Subcommittee of the ECAC Manpower Committee, which will endeavor to evaluate the number of students entering engineering colleges from Liberal Arts Colleges, Junior Colleges, Technical Institutes, and other sources. This information will provide a helpful supplement to the present college enrollment statistics.

Vice President Armsby reported that four out of the five regional Subcommittees of the Society's Committee on Atomic Energy Conferences have held meetings and considerable progress is being made in exchanging information on educational aspects of atomic energy.

Vice President Armsby reported on the meetings of the Engineering Manpower Commission of the E.J.C., recent information released by the U. S. Department of Labor on the Outlook for Engineers, and the Point Four Program of the State Department. He stated that the Point Four Program proposes to ask some of the universities to undertake responsibility for educational phases of the program in certain countries to which teams are to be sent.

Vice President Armsby reported on the proposed plan of the Office of Education to embark upon a new mobilization training program in engineering colleges similar to the ESMWT program. The Budget Bureau is currently considering two proposals. One of these would place the administration of these programs under the U. S. Office of Education, the other would provide for the educational programs to be administered individually by the corporations which have contracts with the government. It was suggested that schools which are in-

terested in this matter express their views to the Budget Bureau.

Vice President Grinter reported that each of the Subcommittees of his Committee on Improvement of Teaching has met. These Subcommittees are preparing preliminary reports and a panel discussion will be held at the first General Session at the Annual Meeting in June.

Vice President Grinter reported that programs have been completed for the Summer Schools in Thermo-dynamics, Engineering Drawing, and Humanistic-Social Studies. A motion was passed that a Division of the Society be permitted to charge a registration fee not to exceed $1.50 per day for those attending the Summer School. Within a reasonable time after the conclusion of the Summer School, the persons in charge would prepare an accounting of the funds received and return the balance to the Society to be allocated to the Division for their budget in future years.

Upon the recommendation of Vice President Grinter, the Board agreed to send copies of the pamphlet "Speaking Can Be Easy" to the conference speakers on the program of the Annual Meeting.

Vice President Terman reported that the Executive Committee of the ECAC met to complete the program arrangements for the Annual Meeting. The ECAC will sponsor the Thursday morning General Session of the Annual Meeting. It is planned to obtain nationally prominent speakers on the subject of engineering manpower for this session. He stated that the Committee on International Relations of the ECAC is planning a dinner meeting of international delegates, and that official invitations have been sent to engineering educators in various countries throughout the world. He also stated that a meeting restricted to ECAC delegates would be held to discuss administrative problems of engineering colleges.

Vice President Rosselot reported that the amendments to the ECRC By-Laws had been submitted to the Research Council membership for balloting. He also reported that the Committee on Relations with Military Research Agencies is cooperating with the Research and Development Board in preparation of a survey of facilities and research potential available in American colleges and universities. It is hoped that this tabulation will be completed by April 1. He also reported that the application of Stevens Institute for membership in the ECRC had been approved.

Proposed Amendments to Constitution and By-Laws

An amendment to the Constitution providing for the establishment of Affiliate Branches of the ASEE in Technical Institutes was favorably voted by the Executive Board and General Council of the ASEE in June, 1950. Subsequently, the members of the Executive Board questioned the advisability of frequent amendments to the Society's Constitution. Accordingly, President Dawson asked the Committee on Constitution and By-Laws to determine whether or not Technical Institute Branches could be authorized under the existing Constitution. The Committee expressed the opinion that such procedure would be entirely legal without amending the Constitution. Accordingly, the Executive Board voted to establish a classification of Branches known as *Technical Institute Branches* in affiliate member institutions of the ASEE. In view of the General Council's previous favorable action on the Affiliate Branch amendments, the Executive Board deemed that it had authorization from the General Council to proceed with specific authorization of Technical Institute Branches. Each institution desiring authorization of such a Branch would submit a request to the Executive Board and final authorization of a particular institute Branch would be by action of the Executive Board. A motion to table the Constitutional amendments providing for Affiliate Branches was passed.

An amendment to the By-Laws of the ASEE specifying the duties of the Treasurer and Secretary was favorably voted by the Executive Board and the General

Council at the June, 1950, meetings. These By-Laws amendments merely formalize the working practice of the Society. The question was raised as to whether these By-Law amendments should be submitted to the membership and voted upon at the June, 1951, meeting, or whether they should be deferred until other Constitutional amendments arise in the future. The Executive Board felt that the previous favorable vote of the Board and General Council were sufficient to define the responsibilities of the Treasurer and Secretary for the present, and that the amendment to the By-Laws could be deferred until such time as other Constitutional amendments seem appropriate.

Revision of the ECPD Charter

The Executive Board voted to recommend to the General Council the approval of the changes in the Charter of the ECPD as recommended by the ECPD on October 20–21, 1950.

Engineering School Libraries Committee Program

The Executive Board discussed a program proposed by the Engineering School Libraries Committee as outlined in a letter of Professor E. A. Chapman. The Board expressed sympathetic interest in the objectives as stated in the proposed program and resquested that implementation of the program be discussed between the Engineering School Libraries Committee and the Section Chairmen.

Annual Meeting, June 25–29, 1951

Dean L. I. Miller of Michigan State College reported on the progress of arrangements for the Annual Meeting at Michigan State College. He stated that Shaw Hall would be available to accommodate 1200–1700 people. Two additional dormitories can be made available is needed.

Dean Miller reported that a "book plan" had been prepared, whereby each person attending the Convention would purchase a book covering the expenses of his room and meals for the balance of the Convention up to Friday noon. Those arriving on the campus Monday forenoon would pay: $25.40 for a man, $23.40 for a woman, and $11.20 for a child. Persons arriving later in the week will pay a proportionately reduced amount. Each book will contain meal tickets for meals. There will be excellent facilities for children, including ice skating and swimming.

Dean Miller stated that adequate facilities were available for conferences, luncheons, dinners, and the Banquet. An attendance of 2200–2500 could be handled on the campus. The luncheons and dinners will be held in the Union Building.

The Executive Board voted to approve the arrangements as proposed by Dean Miller and extended their appreciation to the Local Committee at Michigan State College for their excellent work in preparing for the Annual Meeting.

Publicity Committee

The Executive Board recommended appointment of a Publicity Committee for the Annual Meeting and suggested that Professor Schmelzer of Rensselaer Polytechnic Institute be named as Chairman of this Committee.

Teaching Aids Committee

Professor Muhlenbruch, Chairman of the Teaching Aids Committee, reported that approximately $4400 had been collected for the Teaching Aids Fund. This Committee plans to launch its program of reviewing and evaluating teaching aids in the near future. Professor Muhlenbruch pointed out that some companies have requested technical assistance in the preparation of teaching aids intended for colleges. The Executive Board felt that this was a highly encouraging trend, since it would assure the engineering teaching viewpoint in the construction of teaching aids. However, the Executive Board felt that members of the Teaching Aids Committee, who had assisted companies in the preparation of teaching aids, should not participate in

the evaluation of these particular teaching aids.

Contribution to the E.J.C.

The Manpower Commission of the E.J.C. is being temporarily financed out of contributions from the participating societies. The E.J.C. plans to solicit contributions from industry in order to refund the contributions to the societies. A motion was made to appropriate $407.71 for temporary contribution to the E.J.C. as the ASEE part in this undertaking.

Unity of the Profession

The report of Dean Saville on the proposals of the E.J.C. Committee on Unity of the Profession was considered by the Executive Board. President Dawson urged each of the members of the Board to give the matter serious consideration and report their personal opinions to Dean Saville. The various proposals will be referred to the General Council at its meeting in June.

Journal of Engineering Education

The advertising rates in the JOURNAL OF ENGINEERING EDUCATION were reviewed by the Executive Board and an increase of approximately 15–20 per cent was authorized. The Treasurer pointed out that the advertising rates in the JOURNAL are substantialy below those of similar journals with comparable circulation. The Treasurer also suggested that a substantial increase in advertising in the Yearbook issue might be obtained if it was pointed out to the advertisers that this issue is most commonly used by educators and administrators.

The Executive Board also voted the following increases in prices effective July 1, 1951: Subscription to Journal from $4 to $5; Proceedings from $3 to $4.

The Executive Board reviewed the practice of the Society in granting preferential advertising space to certain advertisers. Advertisers now occupying preferential space have patronized the Society over the longest period of years and have continued their advertising throughout the depression years when other advertisers dropped out. The Board recommended continuation of the present practice. A suggestion that book reviews be included in the JOURNAL was rejected, since if this practice was started, it would be necessary to review books throughout the entire field of engnieering in order to be impartial. This would require a very substantial amount of JOURNAL space devoted to the reviews and would increase the cost of the JOURNAL substantially.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

In Memoriam

Louis Clare Harrington, 71, Dean of the College of Engineering at the University of North Dakota, died suddenly February 3, 1951, at Pittsburgh, Pa. Dr. Harington received his Bachelor of Science degree in Civil Engineering from the University of Michigan and the degree of Mining Engineer from the Michigan College of Mines. He was appointed Director of the Division of Mines and Mining Experiment at the University of North Dakota in 1931 and the following year became Dean of the Engineering College. In 1938 he became actively engaged as a consultant with the U. S. Bureau of Mines and was active in research. His interest in lignite development and friendly cooperation with the U. S. Bureau of Mines influenced the Bureau to build two pilot plants on the campus and finally the Federal Lignite Laboratory, where they will conduct all of their research on the Nation's deposits.

Candid Comments

Engineering Manpower Shortage

Dear Mr. Bronwell:

At a recent meeting sponsored by the Division of Relations with Industry held at Case School of Applied Science, I was chairman of the panel set up to discuss the present manpower shortage. At the meeting it was unanimously decided that our panel should give a brief report to the Society in support of the Manpower Commission of E.J.C. and the Manpower Committee of A.S.E.E.

The consensus was that there were a number of points that should be supported by the A.S.E.E. as follows:

1. Both industry and the schools must assist in promoting high school graduates, with suitable background and ability, entrance into engineering curriculum.
2. Both industry and the schools should assist in providing part time activities for students working their way through college.
3. The A.S.E.E. Code of Ethics must be followed and the colleges should enforce the Code and make it known to all firms using their facilities.
4. Although many colleges already have Alumni Placement Offices, this should be undertaken by all engineering colleges.
5. The Society should wherever possible stimulate the proper use of engineering manpower in the military services as well as in industry, and should support in every way possible the findings of the so-called Thomas Committee as well as the recommendations of the Manpower Commission of E.J.C.
6. We should encourage the armed forces to inaugurate a progression or promotion system in a technical way that would parallel the typical line commission arrangement.
7. Industry should again promote the utilization of training women in the engineering effort.
8. Short specialized training programs should be promoted in the colleges. It is not wise to wait until production suffers in order to establish something like the ESMWT program of World War II.
9. Industry should take immediate steps to eliminate non-technical duties from their engineering activities and utilize trained manpower to the fullest extent.
10. Industry must assume responsibility in the training of men to assist in the engineering effort, must increase the use of graduates of technical institutes and the training of women to take over at least the more routine technical jobs.

In summary, industry, the schools and the military must develop close cooperation to see that the technical and scientifically trained personnel are used to the greatest efficiency. We cannot afford under our existing economy to waste such personnel.

March 6, 1951

M. M. Boring, *Manager*
Technical Personnel Division
General Electric Company

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner, Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University U. S. Naval Post Graduate School	Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
* North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	May 4–5, 1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 27–28, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
* Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

The following applic..tions for membership have been received in the Secretary's Office and have been duly endorsed by two members of the Society.

ABRAMS, JOEL I., Instructor in Civil Engineering, Johns Hopkins University, Baltimore, Md. J. T. Thompson, W. C. Boyer.

AIKEN, WILLIAM A., Professor of History, Lehigh University, Bethlehem. Pa. W. J. Eney, G. E. Doan.

ALI, AHMIN, Instructor in Civil Engineering, Ohio University, Athens, Ohio. E. H. Gaylord, E. J. Taylor.

ANDERSON, EDWIN M., Instructor in Electrical Engineering, North Dakota Agricultural College, Fargo, N. D. H. S. Dixon, R. N. Faiman.

ATWOOD, FRANCES, Assistant Librarian, Northeastern University, Boston, Mass. M. White, W. C. White.

BAER, CHARLES J., Assistant Professor of Engineering Drawing, University of Kansas, Lawrence, Kansas. A. S. Palmerlee, L. O. Hanson.

BAKER, MERL, Assistant Professor of Mechanical Engineering, University of Kentucky, Lexington, Ky. D. V. Terrell, S. F. Adams.

BAKER, THOMAS E., Associate Professor of Social Studies, Case Institute of Technology, Cleveland, Ohio. H. R. Young, W. W. Culbertson.

BARBER, WILLIAM J., Assistant Professor of General Engineering, University of Kentucky, Lexington, Ky. D. E. Terrell, R. E. Shaver.

BECK, CLIFFORD K., Chairman, Physics Dept., North Carolina State College, Raleigh, N. C. J. H. Lampe, E. M. Schoenborn.

BECKER, CARL, Professor of Mathematics, Tri-State College, Angola, Indiana. J. G. Radcliffe, M. F. Rose.

BERGMAN, WILLIAM C., College Employment Coordinator, Michigan Bell Telephone Co., Detroit, Mich. K. A. Meade, A. R. Hellwarth.

BLYTHE, DAVID K., Assistant Professor of Civil Engineering, University of Kentucky, Lexington, Ky. D. V. Terrell, R. E. Shaver.

BOCKHORST, DAYLE F., Instructor in Engineering Drawing, University of Kansas, Lawrence, Kans. R. S. Paffenbarger, L. O. Hanson.

BOSTED, NELSON P., Chief Instructor, Communications Dept., Penn Technical Institute, Pittsburgh, Pa. K. L. Holderman, R. E. McCord.

BOWMAN, CLETUS E., Assistant Professor of Mechanics, University of Illinois, Urbana, Ill. W. L. Collins, A. Q. Mowbray.

BRANCH, JAMES E., Professor of Architectural Engineering, University of Miami, Coral Gables, Fla. M. I. Mantell, M. E. Reeder.

BRANSFORD, THOMAS L., Assistant Professor of Civil Engineering, University of Florida, Gainesville, Fla. J. E. Kiker, F. Bromilow.

BRAY, ROBERT S., Asst. Chief, Navy Research Section, Library of Congress, Washington, D. C. H. H. Armsby, A. B. Bronwell.

BRENNAN, JOHN C., Representative, Personnel, Ford Motor Company, Ann Arbor, Mich. A. R. Hellwarth, D. C. Hunt.

COHEN, RAYMOND, Instructor in Mechanical Engineering, Purdue University, Lafayette, Indiana. B. E. Quinn, J. B. Lusk.

COMINGS, EDWARD W., Professor of Chemical Engineering, University of Illinois, Urbana, Ill. H. F. Johnston, S. Konzo.

CONWAY, JOHN E., Director of Education and Training, A. O. Smith Corporation, Milwaukee, Wis. E. C. Koerper, F. T. Agthe.

COX, DELBERT R., Instructor in Mechanics, Missouri School of Mines, Rolla, Mo. R. Z. Williams, C. L. Wilson.

CROUSE, CHARLES S., Head, Mining and Metallurgy Depts., University of Kentucky, Lexington, Ky. D. V. Terrell, H. Adams.

EDMISTER, WAYNE C., Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. C. C. Monrad, J. W. Graham, Jr.

ELDRIDGE, JOHN W., Assistant Professor of Chemical Engineering, University of Virginia, University, Va. O. L. Updike, Jr., R. M. Hubbard.

ELSEVIER, ERNEST, Instructor in Mechanical Engineering, Duke University, Durham, N. C. F. J. Reed, R. S. Wilbur.

ELSEY, EDWARD E., Associate Professor of Engineering Research, University of Kentucky, Lexington, Ky. L. E. Nollau, J. S. Horine.

ENOS, GEORGE M., Professor of Metallurgical Engineering, Purdue University, Lafayette, Ind. R. N. Shreve, F. L. Serviss.

FARRIS, HANSFORD W., Assistant Professor of Electrical Engineering, University of Kentucky, Lexington, Ky. H. A. Romanowitz, E. A. Bureau.

FEJER, ANDREW A., Professor and Head, Aeronautical Engineering, University of Toledo, Toledo, Ohio. W. S. Smith, W. F. Brown.

FIELD, LESTER M., Professor of Electrical Engineering, Stanford University, Stanford, Calif. F. E. Terman, J. M. Pettit.

FOSTER, CHARLES I., Associate Professor of Social Studies, North Carolina State College, Raleigh, N. C. J. W. Shirley, G. A. Gullette.

FOSTER, L. FERNALD, JR., Instructor in Speech, Purdue University Extension, Indianapolis, Ind. D. C. Metz, E. C. Susat.

FRY, FREDERIC S., Assistant Professor of Mechanical Engineering, University of Denver, Denver, Colo. W. H. Parks, G. O. G. Lof.

FULTON, CHARLES D., JR., Assistant Professor of Mechanical Engineering, Duke University, Durham, N. C. F. J. Reed, R. S. Wilbur.

GOHR, CARL W., Associate Professor of Civil Engineering, University of Maryland, College Park, Md. J. B. Cournyn, L. E. Otts.

GRAHAM, FREDERICK M., Head, Civil Engneering, Prairie View A. & M. College, Prairie View, Tex. C. L. Wilson, L. B. Ryon.

GREAUX, AUSTIN E., Instructor in Architecture, Prairie View A. & M. College, Prairie View, Tex. C. L. Wilson, L. B. Ryon.

GRIFFIN, E. GLENN, Instructor in English, Purdue University, Lafayette, Ind. H. A. Bolz, P. Fatout.

HALIK, GLEN W., Assistant Professor of Engineering Drawing, Michigan State College, East Lansing, Mich. D. M. Fullmer, O. W. Fairbanks.

HARRIS, ANNA M., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. H. H. Clayton, C. F. Strobel.

HARRIS, EDWARD H., Instructor in Civil Engineering, Johns Hopkins University, Baltimore, Md. J. T. Thompson, W. C. Boyer.

HARRISBERGER, EDGAR L., Instructor in Mechanical Engineering, University of Utah Salt Lake City, Utah. W. J. Cope, R. D Baker.

HENSEL, SAMUEL L., JR., Assistant Professor of Chemical Engineering, Northeastern University, Boston, Mass. W. T. Alexander, C. P. Baker.

HEER, JOHN E., JR., Instructor in Civil Engineering, University of Louisville, Louisville, Ky. W. R. McIntosh, W. B. Wendt.

HESSELBERTH, WILFRED M., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. L. E. Beck, G. V. Mueller.

HOUSTON, HASKELL S., Instructor in Drawing, Prairie View A. & M. College, Prairie View, Tex. C. L. Wilson, L. B. Ryon.

HUNTER, KENNETH, Instructor in Engineering Extension, Pennsylvania State College, State College, Pa. K. L. Holderman, R. E. McCord.

ISHMAN, WILLIAM M., Instructor in Mechanical Engineering, University of Miami, Coral Gables, Fla. T. C. Brownell, J. H. Clouse.

JACKSON, HARRY J., Instructor in Mechanical Engineering, Oregon State College, Corvallis, Ore. R. F. Steidel, Jr., L. A. Clayton.

JAMES, RICHARD E., Assistant Professor of Mechanical Engineering, New Mexico College of A. & M., State College, N. M. A. M. Lukens, J. P. Morgan.

JOHNSON, HARRY W., Assistant Professor of Aeronautical Engineering, University of Kansas, Lawrence, Kans. W. M. Simpson, L. O. Hanson.

JURGENS, OTTO, Instructor in Civil Engineering, South Dakota State College, College Station, S. D. E. E. Johnson, J. W. N. Fead.

KECECIOGLU, DIMITRI B., Instructor and Graduate Research, General Engineering, Purdue University, Lafayette, Ind. H. A. Bolz, R. G. Sturn.

KERKER, MILTON, Assistant Professor of Chemistry, Clarkson College of Technology, Potsdam, N. Y. C. Penrose, H. L. Shulman.

KLAMM, CLARENCE F., JR., Assistant Professor of Electronics, U. S. Naval Postgraduate School, Annapolis, Md., H. M. Wright, E. G. Goddard.

KRAMER, LAWRENCE A., Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. D. D. Ewing, E. M. Sabbagh.

KYRATA, FRED, Associate Professor of Chemical Engineering, University of Kansas, Lawrence, Kans. S. A. Mills, L. O. Hanson.

LAMP, BENSON J., JR., Instructor of Agricultural Engineering, Ohio State University, Columbus, Ohio. G. W. McCuen, C. E. MacQuigg.

LECLERC, ANDRE, Assistant Professor of Hydraulic Engineering, Ecole Polytechnique, Montreal, Que., Canada. H. Gaudefroy, R. Boucher.

LEBOW, MILTON J., Assistant Professor of Engineering Mechanics, Wayne University, Detroit, Mich. F. R. Beyer, G. P. Loweke.

LEWIS. PAUL E., Associate Professor of Mathematics, North Carolina State College, Raleigh, N. C. C. F. Strobel, M. H. Clayton.

LOTTES, JOHN C., Assistant Professor of Chemical Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, H. A. Bolz.

MANEY, CHARLES T., Assistant Professor of Electrical Engineering, University of Kentucky, Lexington, Ky. E. W. Bureau, D. V. Terrell.

MANN, JOHN H. C., Professor of Structural Engineering, Virginia Military Institute, Lexington, Va. R. J. Trinkle, J. A. Jamison, Jr.

MARR, ROBERT A., JR., Professor and Head, Civil Engineering, Virginia Military Institute, Lexington, Va. R. J. Trinkle, J. A. Jamison, Jr.

MENGER, KARL, Professor of Mathematics, Illinois Institute of Technology, Chicago, Ill. J. T. Rettaliata, G. Pall.

MEYER, ANDRE J., Professor of Mechanical Engineering, University of Kentucky, Lexington, Ky. E. B. Penrod, D. V. Terrell.

MILLER, CLEOPHAS W., III, Instructor in Electrical Engineering, Prairie View A. & M. College, Prairie View, Tex. C. L. Wilson, L. B. Ryon.

MORGAN, JAMES M., JR., Assistant Professor of Mechanics and Drawing, Virginia Military Institute, Lexington, Va. R. J. Trinkle, J. A. Jamison, Jr.

MUELLER, ROBERT F., Instructor in Drafting, Milwaukee School of Engineering, Milwaukee, Wis. S. A. Eng, A. P. Jones.

MYERS, JOHN E., Assistant Professor of Chemical Engineering, Purdue University, Lafayette, Ind. R. N. Shreve, T. C. Doddy.

NEMECEK, I. W., Assistant Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. H. L. Kipp, A. N. Paul.

OLSEN, LAWRENCE E., Instructor in Engineering Drawing, Wilson Branch, Chicago City Junior College, Chicago, Ill. F. X. Henke, L. F. Prazda.

PAGE, RICHARD T., Assistant Professor of Civil Engineering, University of Kansas, Lawrence, Kans. T. F. McMahon, L. O. Hanson.

PASS, VINCENT L., Instructor in Architectural Engineering, University of Texas, Austin, Texas. W. W. Domberger, P. M. Ferguson.

PENDLEY, LAURENCE C., Assistant Professor of Civil Engineering, University of Kentucky, Lexington, Ky. R. E. Shaver, F. J. Cheek, Jr.

PHILLIPS, EMORY B., Professor of Electrical Engineering, University of Kansas, Lawrence, Kansas. D. G. Wilson, W. P. Smith.

RAMSAY, ROBERT H., Professor of English and Speech, Tri-State College, Angola, Ind. L. S. Ax, J. G. Radcliffe.

REED, EDWARD A., Asst. Dept. Chairman, Industrial Engineering, General Motors Institute, Flint, Mich. H. M. Dent, C. A. Brown.

RELICH, NICHOLAS, Instructor, Technical Extension, Purdue University, Indianapolis, Ind. E. C. Susat, L. Marcus.

RENN, RAYMOND W., Associate Professor of Civil Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, H. C. Messinger.

RENZEMA, THEODORE S., Professor of Physics, Clarkson College of Technology, Potsdam, N. Y. W. H. Allison, F. F. Piper.

RITTENHOUSE, JOSEPH W., Assistant Professor of Electrical Engineering, Missouri School of Mines, Rolla, Mo. I. H. Lovett, D. S. Eppelsheimer.

ROESCH, FRANKLYN W., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, N. P. Bailey.

ROTTY, RALPH M., Instructor in Mechanical Engineering, Michigan State College, East Lansing, Mich. D. J. Renwick, L. C. Price.

RUST, HOWARD O., Assistant Director of Engineering Shop Practice, University of Kansas, Lawrence, Kans. L. O. Hanson, P. G. Hausman.

SANFORD, GEORGE W., Associate Professor of Engineering Administration, Case Institute of Technology, Cleveland, Ohio. H. R. Young, W. W. Culbertson.

SCHAEFER, RODNEY A., Assistant Professor of Mechanics, Missouri School of Mines, Rolla, Mo. R. Z. Williams, C. L. Wilson.

SJOGREN, JOHN W., Associate Professor of Agricultural Engineering, Virginia Polytechnic Institute, Blacksburg, Va. R. C. Brinker, P. H. McGauhey.

SMITH, ROBERT L., Assistant Professor of Applied Mechanics, University of Kansas, Lawrence, Kans. T. F. McMahon, L. O. Hanson.

STEELE, KENNETH, Head, Physics Dept., Tri-State College, Angola, Ind. L. S. Ax, J. C. Humphries.

SUJATA, HENRY L., Instructor in Applied Mechanics, University of Kansas, Lawdence, Kansas. G. W. Bradshaw, D. D. Haines.

TAAFFE, WILLIAM R., Associate Professor of Industrial Management, Carnegie Inst. of Technology, Pittsburgh, Pa. D. F. Miner, J. W. Graham, Jr.

TOULOUKIAN, YERAM S., Assistant Professor of Mechanical Engineering, Purdue University, Lafayete, Ind. J. Hilsenrath, A. A. Potter.

VALLIER, JUSTIN D., Engineer, Educational Service Division, General Electric Company, Schenectady, N. Y. C. F. Lee, W. H. Branch.

WALAS, STANLEY M., Associate Professor of Chemical Engineering, University of Kansas, Lawrence, Kans. J. O. Maloney, F. A. Miller.

WALKER, CARROLL L., JR., Instructor in Engineering, Texas Western College, El Paso, Texas. E. J. Guldemann, F. A. Decker.

WILLIAMS, JAMES W., Assistant Professor of Civil Engineering, Duke University, Durham, N. C. F. J. Reed, R. S. Wilbur.

WILSON, LLOYD H., Assistant Professor of Mechanical Engineering, Washington University, St. Louis, Mo. W. P. Armstrong, C. J. Kippenhan.

WINSBRO, WILLIAM R., Assistant Professor of Chemical Engineering, University of Virginia, Charlottesville, Va. R. M. Hubbard, O. L. Updike.

YOUNG, RICHARD W., Instructor in Electrical Engineering, Catholic University of America, Washington, D. C. J. C. Michalowicz, T. J. MacKavanagh.

ZACHER, CLARENCE H., Instructor in General Engineering, Purdue University, Lafayette, Ind. F. F. Schlosser, I. N. Goff.

ZINK, VICTOR M., In Charge of Speech, English, General Motors Institute, Flint, Mich. C. A. Brown, H. M. Dent.

453 new members this year

The Draft Deferment Policy for College Students*

By RALPH COOPER HUTCHINSON
President, Lafayette College

This statement by President Ralph Cooper Hutchinson, of Lafayette College, was made in defense of President Truman's executive order establishing a college student draft deferment policy based on high scholarships.

"Despite the well-reasoned statements of the President and Gen. Hershey, the distinguished university presidents Dodds and Conant still insist that 'a system of calling up all members of an age group who are physically fit is in accord with American ideals of democracy.' They deplore the deferment of college men with high qualifications, a deferment which is only to prepare these men for more effective service in the armed forces. This insistence is distressing because these university presidents are taken by the public to speak for American education. They themselves make no such claim but their very eminence and distinction serve to create that impression.

"American democracy has never claimed that all men should be regimented in the same pattern, do the same thing at the same time, assume the same precise responsibilities in an emergency, or be enslaved by equalitarian socialism. American democracy has, on the other hand, insisted that each man should do his part, that part for which he is best fitted, and in the time and manner which best serves the needs of our nation and our society.

The Dominant Force

"We are in what is either an all-out war or a protracted mobilization calculated to prevent world war. For the winning of either and the establishment of world peace, we know we must have unprecedented industrial production. This conflict may be won by the nations achieving the greatest scientific progress based upon the soundest and most extensive research. The fire-power so produced, and the transportation to be developed will require the finest and most mature skills for their strategic use. Moreover, it is clear that the idealogical aspects for this conflict may be the dominant force and the determining factor. As none before, this will be a contest of production, science, research, skill, and leadership in action and ideas.

"This means that any immediate expedient which cuts off the development of such skills and leadership is suicidal. First and primary consideration in planning for victory and for the successful preservation of our freedoms should have been the unhampered and uninterrupted training of scientists, production men, medical men, engineers, and qualified leaders for the armed forces and for the civilian programs. First measures on the part of politicians, militarists, citizens and educators should have preserved that thin red line of training of the best students available. First compulsion should have been that these men be required, not permitted, to continue their preparation for maximum service in this war.

* A reply to Presidents James B. Conant and Harold W. Dodds.

"The statement of these university presidents to the effect that the colleges and the college students do not want preferential treatment is correct. But it should make no difference to us what the colleges or the college students want. This mobilization economy should be planned intelligently for the attainment of victory for the forces of freedom. Students qualified and able to study should be prepared for their greatest ultimate usefulness to the armed forces. When they are ready they should be put where they are most needed. This is more nearly the true ideal of American democracy.

Intelligent Use of Skills and Abilities

"To insist, for example, that a brilliant medical student should delay his training for two years or more to carry a gun when he might otherwise go on to the completion of his medical and surgical skills is a stupid interference with the sound prosecution of war itself. It will not hurt the student concerned but it hurts the nation. And it is unfair to the men who will be in the front lines, deprived thus of one more desperately needed surgeon.

"The confusion in Congress and in the colleges is due to the fact that there has been no clear recognition of the primacy of education for the winning of the war. Apparently university presidents are afraid of their own truth for they above all others have failed to enunciate this need for trained men in a great national emergency. Devices for popularity with the voters, the public, the labor unions, the newspapers, and with government officials have obscured our national vision.

"It is time that everyone lay aside political considerations and concern for popular acclaim and think straight through to the defeat of our enemies and the enemies of free nations. It is time that we insist on the immediate, uninterrupted and increased training of doctors, surgeons, engineers, scientists, researchers, and leaders for all phases of military and civilian activity.

"This can be done without impeding the mobilization for the present conflict. Let's get away from this silly debate over socialistic equalitarianism, turn every man to his own task—even the student—let us push ahead, win this war, beat down this surge of human enslavement, and so establish peace on the earth. Such a program is much nearer to the true meaning of American democracy."

The Engineer, The Machine Age, and the World of Tomorrow*

By PHILIP SPORN
President, American Gas and Electric Company

It is commonly accepted that the industrial revolution was initiated in England and that it began roughly with the development of Newcomen's engine of 1705 and more definitely with the improvements made by Watt about 1774. At first this made it possible to do away with human labor for such backbreaking tasks as pumping and hauling. Then came the mechanization of scores of industrial activities: spinning, weaving, fabricating, and many others. And, because the power for these industries had to be developed in large units, the development of the engine eventually led to centralized industrial operations and to the subdivision of these operations, to large centers of activity and to concentration of population at these centers, with some good and many evil consequences.

But no such recognition has yet been given to the new industrial revolution whch was made in the United States of America. This revolution is characterized by machine production, intense technological development, intense specialization, and a much higher rate of production per unit of human effort. That is to say, a great increase in productivity. It has been accompanied by and has enormously stimulated the spreading out of industry beyond the large centers. The development of electric power and its universal availability throughout the United States has been an important factor in this revolution. And an even more important factor has been the relatively negligible cost of the mechanical energy that electric power has placed at the beck and call of every worker in industry to lift and haul, cut and chip, hammer and weld, spin and weave, transform and refine, and to carry out the myriad operations in producing the profusion of goods and services available today.

As a direct consequence of this new industrial revolution, we have a standard of welfare unequaled in history.

American Achievement

Let us look at what has happened here in the United States over the past twenty-five years. In a small table I have compressed into four groups, A to D, a number of indicators of the change in the standard of living during this period. In Group A I have placed two fundamentals—life span and health care. Group B, covering the next four items, shows the data on national income, wages earned, hours worked and the consumers' price index. Group C includes three typical items commonly thought to represent amenities of living—passenger car registrations, telephones and radio sets in use. And finally, in Group D I have given data on two of the fundamental factors upon which the others, more immediately representative of the standard of living, are dependent: electric power production and steel production.

These indicators reflect a most remarkable achievement in the history of the advancement of human welfare. Who can fail to be impressed by the

* An address delivered at the 1951 Engineering Conference, Virginia Polytechnic Institute, February 23, 1951.

SOME INDICATORS OF THE CHANGE IN STANDARD OF LIVING IN THE UNITED STATES, 1925–1949

Group	1925	1949	% Change
A. Average Male Life Expectancy at Birth in Year Indicated	57.8 Yrs.	65.4 Yrs.	+ 13.1%
Hospital Beds per 1000 Population	6.9	9.9 ('47)	+ 43.5%
B. National Income (Billions)	76.0	221.5	+ 192.0%
Average Weekly Wages, Manufacturing Production Workers	$24.37	$54.94	+ 125.0%
Average Weekly Hours, Manufacturing Production Workers	44.5	39 2	− 11.9%
Consumers Price Index (1935–1939 = 100)	125.4	169.1	+ 34.9%
C. Passenger Car Registrations	17,439,701	35,904,770	+ 106.0%
No. of Telephones (Total U. S.)	16,935,918	40,709,398	+ 140.0%
No. of Completed Calls Per Capita	194.9	355.4	+ 82.5%
No. of Radio Sets in Use in U. S.	4,000,000	81,000,000	+1,950.0%
D. Electric Power Production, Total-Billions of Kwhrs.	84.7	344.5	+ 307.0%
Electric Power Production, Total-Kwhrs. Per Capita	743	2,310	+ 211.0%
Steel Production—Short Tons	45,393,524	77,978,176	+ 71.8%
Steel Production—Tons Per Capita	.391	.521	+ 33.3%

fact that in the quarter century 1925–1949 average life expectancy increased 13% and average weekly wages went up 125%, while weekly hours went down 12%. Or by the striking increase of 211% and 33% in per capita production of electric energy and steel—both of basic importance?

And yet, remarkable as this accomplishment is, there certainly can be no question that all is not well with us as individuals or as a nation, nor with the world as a whole. Among individuals, even in this country, there is no general happiness; in the nation there is no pervading satisfying and strength-giving pride of achievement with confident hope for the future; and abroad there is no peace, in many quarters almost no hope. Some would go so far as to say that no hope is being held out for the Western system of civilization—for all of Western man.

How are we to work our way out of the deep morass we seem to have gotten into? How are we to bring under control the forces we have let loose? If it is a fact that our difficulties lie in the failure of our economic, social and moral ideas to keep pace with the growth of technology, can we find our way back by declaring a moratorium on scientific and technological research and development? That has been suggested. Perhaps, it has been said, we can retrace our steps and set up islands of primitive simplicity and self-sufficiency. Is that the answer? Or is the answer an escape into other worldliness and the pursuit of a course that would through a religious revivalism lead to the replacement of our present civilization by a "World wide and enduring reign of the Church Militant on Earth"? That has been proposed by Toynbee.

I must admit that I cannot see any salvation in a return to ancient ways. It seems to me that we cannot go back. If one examines figures of energy, production for the civilized countries of the world, one finds startling discrepancies in individual use. Whereas, for ex-

ample, the kilowatt-hours produced per capita of population is around 2500 in the United States, it is a pitiable 2 in Pakistan, 4 in China, and only 14 in India.

What does this mean? Just this: On the average each human being in a country as technologically advanced as the United States has at his call 2500 kilowatt hours per year. In the less technologically developed countries the corresponding figure is not 1/20th of that value in some of the better cases, and as little as 1/100th in the worst. As a consequence, in those countries the human being is reduced to the role of an energy producer. But how can you reconcile man's humanity or his having been created in the image of God with the idea of valuing him and using him primarily as an energy producer? Keep in mind that the average healthy human being so used can at best produce 1 kilowatt-hour in the course of a twelve hour working day. No, it seems to me that a return to the path of pre-industrial development is not going to make things right. On the contrary, we must continue on the road along which we can lift heavy toil from the back of man.

Nor does the answer lie, it seems to me, in any religious revivalism. That does not mean a denial of the place religion and religous experience can occupy in the growth and enrichment of the human spirit. But I am convinced that such dislocations and maladjustments as we suffer from cannot be cured by neglecting them and going off into another sphere, by—to borrow an engineering term—mixing dimensions.

Which Way to Human Progress?

What, then, is the answer? Which direction can we travel? If we cannot go back to primitive simplicities—and barbarities—and if we cannot escape into a world of other-worldliness—then there is only one route left: continuation along the same route we have been traveling, the route of industrialization and mass production. But, if we follow that course, will that not lead to disaster—some of it almost directly ahead? I am deeply convinced that need not be so. Certainly not, provided we utilize the needs and respect the limitations of human nature as they have developed since the dawn of history, and provided we take advantage of the possibilities of enlarging both raw material supply and production, and the improvements in social relationships as these have been elaborated and tested by human experience. If, in short, we bring to our side a dynamic concept of human capability, if we test it realistically as we go along and if we carry it forward with faith in ourselves and in human progress and our ability to promote that progress.

In her book on the problem of survival facing the west, Barbara Ward observes that the ideas and aspirations of Western man are far from materialistic. They are in fact the most startlingly spiritual forces that have even affected society. Starting with an essentially static world there emerged some 3000 years ago new forces which wrought probably the most radical transformation of the human race since man became recognizable man. These are the Graeco-Judeo-Christian ideas which are the heritage and foundation of our modern Western civilization and in which the basic Greek contribution was rational vision and the Judeo-Christian contribution was moral vision. Out of that there grew man's desire to transform—and his belief in his ability to realize that desire; his desire to create; and his desire to seize on natural circumstance and to change and mold it to the use of man. Looked at from this perspective, it is the ideas of our *Western* civilization which stand out as the truly revolutionary ideas of the world and these are the ideas which must be carried forth if salvation is to be brought to man.

Shall we, then, retrace our steps? Denounce the industrial revolution? Try to arrest the second industrial revolution which in my view has already been going on a long time? Some, like

Norbert Wiener, think we are only heading into the second industrial revolution, but I like to think that it began some 25 years ago and what we are heading into now is merely its full development. This development is going to carry to much greater heights the present mass production techniques. Automatization, of which we have seen a good beginning, will, during this phase, be carried much further, aided by the use of such devices as the computing machine and the vacuum tube. We ought to encourage these trends and developments. At the same time, we need to give them leadership.

Authifarianism vs. Leadership

Where and how shall we get that leadership? It is not likely that we shall get it from those scientists and social scientists who use a secure position of authority in their own special sphere as a springboard for pronouncements about the world at large. Atomic energy has given us some good examples of this habit. Since Hiroshima there has been a great preoccupation with peacetime uses of nuclear energy—and a vast amount of nonsense on the subject by specialists whose knowledge of the world was too limited to furnish them with a sufficiently broad perspective.

We are told by these authorities that if only man were perfect he could now realize all the benefits of an atomic cornucopia, do away with want and disease and secure riches for all. Or again that the world can be set free by the atom if only the world will first set both itself and the atom free. The use of atomic energy for bombs, we are warned, has been allowed to compromise the very necessary potentialities of the long time use of atomic power to replace oil and coal which it is said are within centuries, if not decades, of exhaustion.

It is obvious that these views—taken from a variety of sources, which should be responsible—have this unifying trait: they ascribe almost supernatural powers to atomic energy that simply are not there. Because, stripped of its nuclear physics or the complex chemistry of its separation, and even more of the rhapsodic worship it has inspired, plutonium, U235 or U233, if any of them find use in production of energy, will find application to replace conventional fuels. True, if we can only bring about the solutions of a number of very difficult engineering and economic problems, they may become most superior fuels. Highly concentrated—one pound being capable of developing heat equivalent to that of fifteen hundred tons of bituminous coal —such fuel would be easily transportable. It thus holds out hope of becoming a universally available fuel; and, perhaps, a more economical fuel than coal, oil, or gas. The development of nuclear fuel may, therefore, bring lower-cost heat energy and particularly lower costs of generation of electric energy.

Is that important? Yes, very. But only to the extent that lower-cost fuel is an important item in the cost of electric energy. That means, therefore, that it would be very important in such operations as producing aluminum, magnesium, chlorine or titanium, and of almost no direct importance in ordinary industrial operations or in household use. But this admitted importance is hardly such as to warrant an assignment to the development of atomic power of a value as cosmic as those cited.

Admittedly, atomic energy lends itself to a certain amount of etherealization. In matters more familiar we should logically be more stable. But is there anything less realistic than the fetishism with which many have surrounded hydro-electric power and which is summed up in the remark of an otherwise responsible economist who asserts that steam-electric power is aristocratic while hydro-electric power is democratic!

Scientists, Engineers and World Problems

The remarks of scientists and social scientists to which I have been referring suggest a rather serious lack of compre-

hension on their part of the material world of today. One would expect that the very particulars in which their understanding is most inadequate could best be supplied by the engineer. After all, he is the one who developed and applied the machine technology which is the Western world's most conspicuous characteristic. One wonders why he does not have a larger share in providing the leadership which that world so desperately needs. Actually engineers are hardly represented at all in leading roles in public affairs.

The Cabinet of the most powerful democratic nation does not include a single engineer. In the 81st Congress of the United States there were only 7 engineers out of 432 members, while the legal profession, for example, furnished 259 men. There were only 5 engineers in the Senate, as contrasted with 66 lawyers. Or consider the sobering fact that among the commissioners of the three perhaps most important administrative bodies in the executive branch of the government—the Securities and Exchange Commission, the Federal Power Commission, and the Atomic Energy Commission—there is only 1 engineer, who serves on the Atomic Energy Commission.

I do not pretend to know what accounts for the engineer's aloofness from public activities. Perhaps it is simply that the environment of politics—in the best sense of the term—is too alien an atmosphere for one who has been taught to believe that the world is composed of solid facts, that its variables can be balanced by contingency factors and that any compromise is questionable. Whatever the ultimate cause, it seems to me that engineering is not widely represented in public affairs because engineers, consciously or unconsciously, have elected not to make the effort necessary to become involved. This condition ought to be corrected if, as I believe, the engineer has been and is the instrument through which the second industrial revolution is being accomplished.

Broadly speaking, responsibility for this inertia of engineers in public affairs, rests with the present generation of practising engineers. In saying this I mean that in the final analysis it is they who must be held responsible for the condition of our technical schools. They are the ones who propagate the new generation, and they propagate in their own image. What are they setting up as their image? In general, the definitions of engineering adopted by engineers stress the technical aspects of the field, and frequently along quite a narrow beam. The engineer thus restricts himself to the cramped role of technician. He does not even allow himself the breadth of field that goes with the concept of technologist.

Education and Outlook

Where does this narrowness of view and aim start? At least as far back as the beginning of the future engineer's technical education. It may well go farther back and have its beginnings in the preparatory or high school. It may very well be that here is molded in almost permanent form the ideas that engineering consists solely of the application of science to the design, construction and operation of machines and equipment or to the carrying on of process "for the aid and convenience of men"; that those studies and interests which contribute directly to these stated aims are proper and should be encouraged; and that other studies and interests are not only divagational but are somehow soft and inconsistent with such an obviously manly profession as engineering.

If that is so, then as far back as the upper levels of our preparatory schools it is necessary to introduce curricular changes which will emphasize the potential breadth of engineering and the engineer's role, and stress the socio-economic usefulness and importance of technologists in modern society. The future engineer must be made to see not only that he will join a profession of technologists but also that he should become an in-

fluential member of the much broader group who together are the architects of social progress, a circumstance that gives them boundless opportunities.

Equally important, we must make it clear that the very magnitude of the potentialities imposes heavy responsibilities on those who as educators undertake the task of molding and guiding the development of our future engineers. For it is the teachers in the preparatory schools who can best plant the idea that the role of the engineer is fully consistent with knowledge and understanding of the social sciences and the arts. As a matter of fact, I think the case warrants much stronger statement. A thorough grounding in the humanistic disciplines is indispensable to the engineer's full development and to his assuming any real leadership in the world of today.

The place to begin on this new road is the secondary school, but that is only spadework. The real work must be done in the engineering college or technological institute. And this will be impossible unless we recognize squarely that by and large our engineering education has tended altogether too heavily toward the vocational. The curricula in the schools that propose to train engineers in the fullest sense must be broadened; more time should be devoted to social sciences and humanities. This may mean a reduction in time devoted to the specific engineering subjects—the subjects which are supposed to impart practical know-how. But, if a choice has to be made between this know-how and the acquisition of broadly based knowledge of society, past and present, the answer should not be difficult. Not know-how, but an understanding of the process for acquiring know-how and how to use know-how is what we have to aim at.

The last, it seems to me, is of particular importance. There is a general feeling, certainly prevalent in the United States, that we have in the past absorbed too many facts and thought about them too little; this applies with particular pointedness to engineers and engineering education. A great Polish scholar and philosopher who lived and taught among us for many years first pointed out some 30 years ago that the essential characteristic that differentiates man from plant and animal life was that, whereas plants possess chemistry binding abilities and animals space binding qualities, man is the only creature on earth who possesses the unique capacity to accumulate knowledge. The engineer trained in science and engineering is apt to over-idealize this time binding characteristic of his profession. For there also exists in human experience much knowledge that is non-cumulative in the sense that the engineer's analytical methods and procedures, equations, formulae and tables are completely cumulative. The knowledge relating to literature, philosophy, music and art is of a quite different and infinitely less palpable kind. The broadening experience of these, no less than strictly technical study, is needed by engineers who want to assume a part in leadership in the world of tomorrow.

A significant step in expanding the scope of engineering education has been taken within the past year. Several of our leading universities had already demonstrated that the integration of technical schools within the university community, and the resultant close association between technology and the liberal arts, can do much to increase the effectiveness and vitality of all concerned. The new step is an extension of this idea. The idea is to enable the Institute to broaden and deepen its activities in these fields and to educate men to be effective citizens as well as effective professional engineers—to be, in other words. technologists and engineers and not mere technicians.

The mechanism for gaining this objective need not necessarily be the same in other engineering institutions, but the basic idea needs to be developed and implemented by many more schools. I haven't any doubt that only after this

is done will we succeed in establishing a satisfactorily broad foundation for training the better rounded engineers that the future demands.

Nor can any program for enlarging the scope and vision of our engineer stop with the schools. The present generation of mature and successful engineers have a responsibility in this process also. This involves the closer integration of the engineers with one another and with the professional schools and colleges: each with his own alma mater, most naturally, but also with the other institutions that his work and practice naturally bring him in contact with. So many engineers of outstanding ability, upon reaching maturity, rush headlong along a road that will keep them as far away from engineering as possible. In doing that, they separate themselves from engineering and engineers, and also from their problems and the institutions where these problems are being worked on. While many of the engineers in this group would be emphatic in their denials of any such intent, they nevertheless generally imply that the profession and practice of engineering is not quite a satisfying occupation, although it may be an excellent stepping stone to some "higher" or at least more "responsible" form of activity.

This, it seems to me, is a great pity. Because I believe that out of such judgment and action the engineers who have advanced in their profession not only lose an opportunity for spiritual expansion and satisfaction, but—and this is when the common welfare suffers—they fail to give the younger generation of engineers what they might otherwise be able to transmit of their own growth and development.

Such men cannot only teach and contribute by precept and example but also have an opportunity to propagate one of the most important ideas that needs to be implanted in the mind of the young and younger engineers—the dynamism of engineering. The tendency toward overawing the young engineer with the vast amount of accumulated knowledge that he has to acquire in turn tends to sterilize his creative faculties before they have had an opportunity to blossom. It is the older generation of engineers who can furnish out of their experience the necessary distillate to avoid such deadly thinking and to establish the vitally important truth that what an engineer learns in his years at school and in his early years of practice about what others have done before him is but a prelude to what can be done and what is open and possible for him to do as he matures in his profession.

It is the engineer educated in the basic sciences, the humanities and the social sciences and thoroughly grounded in engineering principles and ideas, who will find opportunities for constructive leadership. The engineer who is equipped initially with enough tools to begin working in his profession but who more and more relies on new ones that he acquires as he goes along—he is the engineer who can stay buoyed up by the spirit of growth and progress and who can imbue others with this spirit. It is this engineer, with his knowledge of the machines that characterize and make possible the world of today, who can not only help create the world of tomorrow but who, taking his proper place in public affairs, will also help run it for the physical benefit and spiritual advancement of man.

Building an Engineering Curriculum

By JOSEPH WEIL
Dean of Engineering, University of Florida

Someone has said that the ideas of a bride and a groom differ about weddings. So, too, do the ideas of what should be contained in an engineering curriculum insofar as students, alumni, and faculty are concerned.

The Engineering Council for Professional Development has given much thought to the development of a new brochure entitled, "The First Five Years of Professional Development." The first line in this book states "The most important person in this country today is the young man who has potential." It is the purpose of this discussion to consider what is needed to build an engineering curriculum to fit his needs so that upon graduation he can avail himself of the excellent information, counsel and guidance that he can secure from books.

A college curriculum should be designed so that it gives to the graduate an education that enables him to enter into his chosen life's work well-prepared. Certainly, it is not the purpose of the college curriculum to be a complete education, but rather it should be a basic education which will enable him to continue to add to his fund of knowledge and to grow in his chosen profession. Engineering is growing fast, and as it grows its literature becomes increasingly larger in magnitude and reading it becomes more complex. Only if the educational program is planned so that the fundamental sciences—physics, chemistry, and mathematics—become basic knowledge to the individual, can reading of technical literature be carried on with the necessary facility and interest.

Curricular Problems

What courses shall an engineering curriculum contain? The student for the most part would like to spend his entire time in the shop and laboratory and take classroom material which deals solely with machines and materials. If the engineering alumni group were contacted they would indicate that courses in speech, economics, psychology, law, advertising, humanities, sociology, etc. should be included in the curricula. The comparison of curricula of today with those of twenty years ago reveals some interesting factors. There seems to be no question but that a large amount of non-technical material has been included. Since the program, in general, is still a four-year one, it might be thought that these courses have been included at the expense of fundamentals and technical material. I do not believe that this is the case. I feel that the courses in physics, mathematics, applied mechanics, chemistry, are more comprehensive than ever before. Fundamental engineering courses of applied mechanics, thermodynamics and hydraulics are given in as great detail now as then.

In planning an Engineering curriculum, we must recognize that only a portion of our students become professional engineers. It is estimated that in June 1949 there were approximately 300,000 engineers of whom 150,000 were registered. I would hate to hazard a guess as to how many of the graduates of our engineering schools are earning excellent livings in either non-engineering work or in work closely allied to engineering who were not numbered among the 300,-

000. It would seem to me that the number would be at least twice as great. Has an engineering education been a loss to these men—unhesitatingly I would say "no." But I do feel that for many of these men it would have been better if they could have substituted for some of the material now included in our senior year more non-technical subject matter. In this technological world in which we live, it would appear that just as there is a real place for general curricula such as are given in the arts and sciences colleges where degrees such as Bachelor of Arts or Bachelor of Science are awarded, there is similar place today in our engineering schools for a non-professional degree which might be called a Bachelor of Technology. Such a degree should not be confused with the so-called General Engineering degree which has been given, tried, and in many cases dropped.

The responsibility of the engineering college is basically far greater than to train the young man for mere technical proficiency. It must give him a general education that will make him cognizant of the underlying factors which affect our modern sociological and industrial world—for only as a well-educated professional man can the engineer of today assume a place of leadership in modern society. If he is to have a voice in the control of his brain children, he must be prepared, first of all, to be a good citizen. A broad and well-balanced curriculum should lead not to the production of mere technicians but to the making of well-rounded professional engineers. Properly trained professional engineers should be able to bring the findings of the laboratory into practical use. As the basic scientist uncovers new laws, it is the engineer who must make them available to mankind in a practicable manner. The successful engineer of today must not only know how to handle machines and materials, but must also be able to plan from the economic and sociological standpoints as well. To create products for an already full market will lead his employer to financial ruin. To manage employees in an unskillful manner leads to strikes. There is a feeling among many educators that we are including in our curricula neither sufficient technical matter nor enough educational material of a non-technical nature.

What is there about the engineering profession which gives us the right to believe that we can do by our educational process in four years what the other professions take six to eight years to accomplish? It is true that the graduate from our engineering school must serve an internship in engineering, but I think that is also true of most other professions. Should we give a course which would lead to a degree of Bachelor of Technology in four years and the Bachelor of Engineering degree after about two more years of study? I feel that this latter bachelors degree in the engineering subject should cover about the same professional content that our present bachelors degree covers but that there would be more material given of a non-technical and humanistic nature and that there would be more time devoted to the fundamentals of mathematics, drawing, English, physics, chemistry, mechanics, thermo-dynamics, hydraulics, etc.

On the other hand, it is not the purpose of this paper to discuss such a degree at this time. There are a large number of educators who are in sympathy with a change of procedure as indicated but who feel that they are forced to follow into paths which have been blazed by so many of our eminent engineering educators of the past.

In curricula building, it must be taken into consideration that the basic work of an engineer is to design or to apply a knowledge of design to his work. It is probably in this one respect that an engineer differs from all other professions in that he applies his knowledge of the basic sciences and the social sciences with his skill in order to design or to apply design principles. The engineer in charge of the construction of a bridge must have design knowledge in order that he can properly interpret the de-

sign which is handed to him; this is also true of many persons in operation, management, and other fields. If our curriculum is planned solely to meet this definition of an engineer, what can be said for perhaps 60% of our graduates who enter fields contiguous to engineering and who use a minimum of design principles? I think that everyone would agree that it is not the purpose of the engineering educator to eliminate from consideration these men, but full cognizance should be taken of the worthwhileness of the work which these persons are doing and that as we plan engineering curricula their needs also must be met.

Degree of Specialization

Another criteria of curriculum building is based upon the degree of specialization we should try to achieve. During the past century we have departed far from the original concepts of an engineer and today we are considering more and more detailed speciality groups. The attitudes of many colleges vary in this matter. Some have specialized to only a very moderate degree and few fields of specialization are offered, while in other cases there appears a staggering multiplicity of specialties. In some cases a form of specialization has been carried in another direction in that mathematics, physics, and the other basic sciences have been held to a minimum and what might be termed shop courses have been expanded. Under the guise of practicality, the program borders upon that of the technical institutes.

Basically, therefore, in setting forth certain criteria that we should consider in the forming of a curriculum we can certainly include the following: 1. The curriculum should be planned so that the graduate can engage in work in engineering fields under the direction of experienced engineers and can be of definite assistance to them in the same manner as the young physician serves as an intern and resident. 2. Furthermore, his education should be of such a type that after approximately four years of such internship he should be ready for rather responsible engineering assignments and should be able to appear before the examining board of any of the states and be in a position to successfully pass an examination for registration as a professional engineer. 3. The engineer, as an educated man, must have the ability to read and to appreciate the literature and philosophy which is so important a part of our modern civilization. His education should be of such character that it will enable the graduate to consider himself as a professional man who can live and associate with other professional men, discussing with ease and confidence the normal problems which such men as leaders of a community would normally discuss. It should not be limited solely to the mere technological aspects of his profession, but must recognize that the engineer as a citizen should take his responsibility for the governmental functions and social operations of the community.

It has sometimes been stated that the principle professional tools of the engineer are five: facts, concepts, principles, techniques, and judgment. Certainly in the planning of any engineering curriculum the first three of these have an important place. I think it will generally be conceded that the last two are secured primarily from the field of experience. Many years ago in discussing the work of the engineer I stated that upon graduation the young engineer will probably be employed on some project or in some factory where he will work primarily with machines and materials. If he does his work well, a time may come when in order to speed up production men will be assigned to him to assist him in speeding up the work. Then he must use the best methods of securing the best production with these additional men. Then, as he successfully performs in the new assignment, he will be given more and more administrative responsibilities and he will have to consider fiscal matters—money. And so the growth of

many engineers is along a path of Machines, Materials, Men, Management, Methods, and Money. Certainly, the handling of these six M's is part of what is termed the engineering method. What courses should be inserted in the curriculum to help the student not only during the first part of his path, but which courses will be of value to him as his path broadens?

Another aspect of the planning problem which I think should be given considerable emphasis is that since it is generally conceded that design is a very unique criteria of the engineering form of education, anything which can be done to further the student's design and professional consciousness must be considered as most worth-while. With this in mind, many schools have found that a thesis which involves some research or design i excellent for motivating the student in this general direction. Certainly, that student who selects some problem which differs from those of his colleagues and then endeavors to secure information which would enable him to write a thesis on the solution of that particular problem secures a feeling of professional well-being and creativeness that he cannot secure from stereotyped courses.

Selection of Major Field

Certainly a few decades ago, a student chose his major option. Then, having selected that option there were no electives and the courses that he had to take were assigned to him on the day he entered college. In the recent years, however, there has been a shift from that general direction and most of the schools do provide some electives. The choice of these electives varies with many schools. In some cases these are misnomers. While the word elective appears in the catalogue, the faculty advisor of the student practically forces him to take the courses that the department advises are needed for that particular field of specialization. There is a general feeling among educators today that the required essentials of every curriculum should be held to a minimum and the student given the opportunity to elect subject material which he feels will be of greatest benefit to him. We all recognize the danger of the student steering far away from that field in which he should take more work, to clear up deficiencies.

But then, too, in many cases it may be found that the responsibility for such decisions rests in no small measure with our own educational system. The engineering student is a serious one, and I think that given proper counsel, he will endeavor to build a curriculum for himself which he believes will give him the subject material which he needs most for success in his life's work. It has been our experience in counseling students that while at first considerable reticence is shown by many men in taking courses which we believe they need, by patient and continuous counsel most men recognize their needs and volunteer to take the courses.

The curriculum should be frequently studied and revised. However, it should not be done so often that the entire set-up is in a turmoil at all times. It seems that, in general, a curriculum can be kept fairly stable for a period of about five years, and changes that must be affected in that interim should be relatively minor. I recognize that there are many people who feel that instead of having a considerable shift of curriculum material all at one time that it is better to have it come in gradually. However, over a five-year period the total amount of change should not be very great and the number of course changes should not be too radical if the period be limited to this time.

The Faculty in building a curriculum must not overlook the fact that occasionally an instructor is particularly competent in some specialty field. Whenever this occurs—frequently when a new man is added to the faculty—there is an immediate urge to place into the cur-

riculum a number of new courses in specialty fields. This is certainly one way in which a curriculum may become overburdened with specialties to an objectional extent. On the other hand, it certainly should not be said that these experts should not be given an opportunity to present some of their specialty work as electives to students who wish to elect specialty courses in those fields. There is a stimulus and awakened interest which occurs when people deeply imbued with their subject matter endeavor to pour forth their knowledge. This type of work must be held in check, and certainly in many cases, it should be withheld for the graduate program.

While in the definition of an engineer the term "to design" is emphasized, this should not be taken to mean that it becomes the purpose of the curriculum to train a man to be a skilled designer. If the engineering curriculum is properly planned, there would not be sufficient time to do this and there are many other reasons why this can best be done after a man leaves college. However, the curriculum should be planned so there can be no question but that the student receives the fundamentals of engineering science which will enable him to grasp with considerable facility design technique after he leaves college. Through experience so obtained he will gain the requisite knowledge needed for his professional work.

In the building of a curriculum we must take cognizance of the fact that we have a responsibility not only to provide the technical content of the curriculum but also to provide for the ethical phases of professional engineering while the student is in the most formative period of his entire career. If the engineering profession is to become increasingly greater and command the respect of the non-engineer, there must be developed in the student a feeling of professional consciousness. It is not, perhaps, necessary that formal courses in ethics and professional practice be included in the curriculum. Nevertheless, it appears to be an essential duty of the educator to definitely determine that somewhere in the curriculum emphasis will be placed on such subject material as will awaken in every student a professional consciousness that shall stand him in good stead during his professional career.

We can liken the building of a curriculum to the building of a beautiful edifice. Such a building might be considered by several groups of architects and builders. The same material might be available to all of them. Yet, the edifice that would be completed would be entirely different in each case. On the one hand, it might be a beautiful building structurally strong, aesthetically beautiful, and functionally excellent. On the other hand, quite the opposite might be true.

The same course material might be available to several groups of educators in various institutions; and the completed curriculum may be apparently similar but yet would produce entirely different results. Besides the material contained in courses there is a philosophy together with many intangible factors which combine to produce the final results. If we pick up a catalogue and read a curriculum and then compare it with the curriculum contained in another catalogue, it will frequently appear that both are the same. Yet, there can never be an evaluation of the intangible factors which are a part of each of our educational institutions. It is, in no small measure, due to these intangible factors that our graduates now go forth from our American institutions to serve well—graduates of whom we may well be proud.

The Case Method of Teaching on the Senior Level

By J. F. MANILDI

Assistant Professor of Engineering, University of California

It is a common failing, in engineering instruction, to try to teach too much. The supply of courses generally available tends to exceed by far the basic requirements of an engineering curriculum. Competition is keen for the inclusion of specific courses in required curricula. The instructor frequently feels that he must at least make the student aware of all the refinements of a subject with which he (the instructor) is intimately familiar. The instructor may tend to forget that it took him years of study, teaching, and possibly industrial experience to acquire the knowledge himself.

It must be remembered that four or five years of college training by itself cannot result in turning out a "finished" engineer. The most that can be hoped for is that the product of college training will be well qualified for a period of "apprenticeship" in his professional field. The industry is quite realistic in its attitude toward graduating engineers in this respect. It does not expect that the new graduate will be capable of handling full scale technical problems, much less problems involving questions of policy, finances, management, personnel, etc. Nevertheless, the graduate must be capable of growing in ability and stature to the point where he can handle these problems, or he cannot be considered to be a success in his profession.

The function of a college training in engineering may thus be considered to be to reduce to a minimum the "growing pains" associated with the graduate becoming a full fledged engineer, and to equip the student so that the transition may be accomplished in a minimum of time consistent with the students' native capabilities. It is virtually impossible to eliminate these "growing pains" for doing so would be tantamount to turning out of college an accomplished engineer.

To accomplish the feat of properly training the student for his "apprenticeship," the standard college curricula prescribes instruction in the basic sciences: mathematics, physics, and chemistry. It further prescribes instruction in the basic engineering subjects of mechanics, thermodynamics, electrical theory, fluid mechanics, properties and strength of materials. There is general common agreement that these are necessary.

A third group of courses are the so-called "electives." Courses of this type are designated either to give the student more specialized knowledge in his selected field of engineering, or to broaden his scope of learning in related fields. In either case, the objective is the same, namely to train the student so that his subsequent attainment of full professional engineering stature will be accomplished in a minimum of time with minimum growing pains. The method of accomplishing this objective is quite obviously different in the two cases. In contrast to the general engineering subjects mentioned above, there is a wide divergence of opinion on the type of courses that should be offered in this third group.

A course which we shall call Engineering Problem Analysis, as described below, falls into the third category and is the type of course designed to broaden the

students knowledge rather than to specialize his learnings.

Description of Course

The proposed course in Engineering Problem Analysis would consist of the presentation, discussion and analysis of typical industrial problems. The case method of instruction would be used throughout, with no attempt being made to present any formal instruction. No effort would be made to graduate the material in order of difficulty or complexity. The typical course would consist of three or four one-hour class meetings per week, or possibly two two-hour classes per week.

A total of from five to ten cases would be analyzed each semester. The cases selected for analysis would cover as many phases of engineering as possible with the time available. Cases would be selected, with as little modification as possible, from actual industrial problems. As far as practicable, different cases would be discussed each semester. This would insure up-to-date material for the course, and would suppress any tendency for instructors to guide analysis toward "pat" solutions previously worked out, thus suppressing original initiative on the part of the students. Experience in teaching the course would, of course, constitute the most effective guide to the selection of cases.

The cases themselves might vary widely in nature. For example, a case might deal with the design of an instrument required to do a specific task, or of the design of a particular component of a machine. At the other extreme, a case might deal with the inauguration of a full scale research program in a broad field of endeavor associated with a company's activities, such as the oil refining or aviation industry.

Every effort should be made to include all significant factors in the presentation of the problem material. It would be desirable to simulate as closely as possible the situation as it would actually exist in industry. Thus, not only the technical features of a problem, but also the pertinent economic, personnel, scheduling, plant facility, customer relations, and sales features of the problem as well.

The techniques of classroom instruction would be directed to encourage a maximum of contribution from the students with as little guidance from the instructor as the situation would permit. It would be desirable to use several men to teach the course, each presenting a case problem drawn from a field with which he is intimately familiar. Group participation in the solution of problems should be encouraged or even required. Solutions could be presented informally, orally, in class by individual groups, with criticisms from other members of the class or solutions could be presented formally in report form. A combination of both methods would probably be most effective. The instructor would act essentially as a moderator in this activity, keeping the discussions along constructive lines and furnishing factual information whenever desirable.

The usefulness of examinations in a course of this type might be questionable. One hour class period would not lend themselves to case problem solutions. The two-hour period would be more adaptable to examinations. Useful information regarding a student's accomplishments might be gained in a three-hour final examination. However, the necessity of examinations in a course of this type is highly questionable. Effective handling of the subject matter would require that enrollment be kept low, probably not more than twenty students per class. The course administrator would probably have little difficulty, without examinations, in judging the accomplishments of the individual students from the classroom discussions and the written reports.

Objective of Course

The basic objective, of course, in presenting students with a course of this type, is to better his adaptability to in-

dustrial problems and environment, and hence to increase both his initial and ultimate contribution as an engineer. The specific, immediate objectives, through which it is hoped that the basic objective will be attained, can be described as follows:

(a) To train students to synthesize the technical knowledge obtained in separate undergraduate technical courses. Students ordinarily capable of handling textbook problems in electrical theory, or thermodynamics, or fluid mechanics are frequently at a loss in attaching broader problems involving considerations from all these fields. This is one of the present failings of our engineering curricula, due primarily to lack of coordination among the separate subject matter courses and to an unhealthy tendency to depend too strongly on "canned" textbook problems for instruction.

(b) To enable students to acquire a facility for handling problems which they have not previously encountered. The difference between success and failure in a job assignment is often dependent upon the degree to which a man can readily adapt himself to a totally new set of conditions. There exists an understandable psychological tendency to use familiar methods of approach on new problems, or, worse, to be frightened into inactivity by a totally new situation. This tendency must be understood and overcome before any measure of success can be attained by a man on the job.

(c) To impress the students with the necessity of "selling" their recommendations or proposed solutions to problems. Altogether too frequently technically trained and competent men feel that their job is done when a well-executed analysis has led to a reasonable set of conclusions. The fact of the matter is that this is only the first step in the ultimate execution of the plan. Alternative methods of approach may, and generally do, exist. The engineer on the job must make every effort to sell his recommendation to his superiors, who, in many cases, may not be technically trained, or his proposal, however good it may be, may die an unnatural death in a filing cabinet. This necessity, in our present day of competitive enterprise, of selling a recommendation, is as real and important a responsibility as the more generally recognized responsibility of performing a consistent, satisfactory analysis. This is a responsibility which must be recognized and met if advancement in stature and position is to ensue. Our present training of prospective engineers leaves much to be desired in this respect.

(d) To acquaint students with logical, rational methods of handling problems that have no single "answer." Many problems, in fact, most problems encountered have many possible solutions. The number of variables involved generally vastly outnumber the quantitative relationships among these variables. Many existing relationships, particularly in connection with economic and personnel factors, because of their complexity, cannot be adequately represented quantitatively. Intelligent estimates, enlightened guesses and methods of approximation must be resorted to and these must be supported by convincing reasoning. It is not to be supposed that a student can be taught to do this adequately, since experience is the most valuably ally in solving such problems. Nevertheless, an appreciation for the necessity of using sound basic reasoning, rather than "handbook methods," can be taught and can result in the student's being much better prepared to handle problems of this type.

(e) To teach students to formulate the specific problems which must be attacked to arrive at a satisfactory set of recommendations with respect to a broader, more general problem. Present engineering education places a heavy emphasis on solving problems that are adequately stated, with little or no emphasis being placed on the formulation of problems. The young engineer thus frequently finds himself at a loss because no one tells him what he should do. The exercise and development of ingenuity and imagination in the formulation of

problems is as important as the ability to solve them once they have been stated.

(f) To teach students a little of the "art" of engineering in various fields. It is generally agreed that the "know-how" of engineering must be predominantly acquired through experience, and that is much more difficult to teach than the science of engineering. Nevertheless, by having case discussions led by men of wide experience and competence in their respective fields, it is possible to pass on a limited amount of this "know-how" and thereby to reduce in some measure the growing pains of the new graduate.

(g) To acquaint the student with the importance of recognizing his own limitations. One of the major difficulties which confronts a young engineer of little experience is that of deciding when a problem requires the application of knowledge or abilities which he does not possess. This situation is made increasingly difficult because it is not readily distinguishable from the case where he is giving up too easily because the problem only seems to be beyond the grasp of his capabilities. Danger lies in the application of to little knowledge to a situation requiring a thorough understanding of a phase of subject matter. There is a delicate balance between giving up too easily on one hand and recognizing the necessity for more competent help on the other. Doing the former or failing to do the latter are both sins which have an adverse effect on the reputation and advancement possibilities of the engineer.

(h) To teach students the importance of deciding in advance the desired degree of accuracy required in a problem analysis, and to plan his method of attack accordingly. In all problems it is necessary for the analyst to postulate an ideal system which approximates the actual system, and which is amenable to quantitative analysis. This is true even in the simplest problem, such as the problem of predicting the frequency of oscillation of a mass suspended from a spring. The degree of difficulty of the solution, as well as the probable error in the final answer or recommendations, depends on the complexity of the postulated ideal system. Unnecessarily complex postulates result in an expenditure of time and effort not warranted by the specific problem at hand. Furthermore, the analysis tends to be less readily understood by others, and the problem of selling the recommendations to superiors who are not so highly specialized in the field is a more difficult one. On the other hand, over-simplification of the ideal system will result generally in solutions having too great a probable error, and completely erroneous conclusions may be drawn therefrom. In this connection checks by alternative, approximate, methods of solution are highly desirable and should be encouraged.

(i) Other objectives may be indicated, such as teaching students to make full use of all available data, to work effectively in groups, to express himself orally and in writing clearly and concisely, and to recognize and carefully evaluate suggestions of others. These are self evident and will not be discussed in detail here.

Objections to Course

There are many objections which may be raised toward the presentation of such a course on the senior level. Some of these are anticipiated and will be discussed.

The displacement of other subject matter from the curriculum may constitute a valid objection. It is difficult to make any generalizations in connections with this objection, since the desirability or undesirability of replacing a particular course with the course described above would depend on the specific course which would be replaced. The responsibility of making a decision cannot be avoided by simply making the course an elective, since staff members must advise the students in making an intelligent choice.

The objection may be raised that it is not possible to present students, in a problem statement, with all the facts that he would normally have at hand in the actual industrial situation. This, of

course, is true. This objection is not as significant as may seem at first, however. An engineer is never confronted with a problem in which he has all the desirable data. There is always information, technical or otherwise, which would be useful in arriving at a solution, but which is not available. It might thus be argued that this lack of data which would normally be available is a blessing in disguise in that it tends to emphasize an existing situation and the student will be made more acutely aware of this ever-present characteristic of actual problems in industry.

It may be proposed that a course of this type will tend to severely confuse a student with too great a mass and too great a variety of material in a short time. It must be admitted that herein lies a real danger. In order to justify its existence, the course must be capable of instilling in the student a reasonable degree of confidence in his own ability to attack situations presented in the case material. To confuse the student, to make him doubt his capabilities would indeed constitute an overpowering objection to the existence of such a course. In this connection, it can only be emphasized that the selection and administration of case problem material must be done with great care. The course administrator and the individual instructors must work together very closely. More individual attention must be paid the students by the instructor than is generally necessary in other courses. Individual student shortcomings must be recognized and corrected. Otherwise, an adverse effect may result. It is true that at the beginning of the course, even the better students will tend to be confused by the problem material. This is not objectionable as long as the confusion and insecurity disappear and is replaced by confidence before the course ends.

It is possible that a course of this type may tend to give the student a distorted impression of the type of activity in which we will be engaged when he first gets a job. He may become dissatisfied, in retrospect, with the course, or with his job, when he finds himself doing strictly routine work. This difficulty can be overcome very readily by making it quite clear to the students at the onset of the course that the course is intended to enhance his long range achievement potentialities, and that no specific effort is made to prepare him for his first job.

Past Experience

The basic nature of the course discussed above is certainly not new. Many graduate schools, notably in law and business administration, have depended entirely on the case method of teaching in their curricula. The results, in these instances, have been highly gratifying, since adoption of the method is increasing. Engineering graduate schools have used the method sporadically and no good information is yet available as to its relative effectiveness. The Carnegie Institute of Technology, at the instigation of President Robert E. Doherty, has for some time presented on both the graduate and undergraduate level a modification of this type of course. At Carnegie, the emphasis is placed more heavily on the strictly technical features of a problem.

Courses of this type have constituted a part of the General Electric Advanced Training program for many years. This may constitute a recognition from industry that the normal engineering program at universities lacks in this type of training.

Conclusion

A course of the type described aims at filling into an engineering curriculum training of the type that is normally lacking. This training revolves around the simulation of actual industrial situations. Basically, it is hoped that a course of this type will make the transition of a graduate from an engineer-in-learning to full professional status, easier. Further, it is hoped that his potential of attainment in the profession will be increased.

The course is not proposed as a cure-all. As a matter of fact, it is proposed with the knowledge that certain adverse results may obtain. It is clearly recognized that the attainment of the specific objectives listed above, with a minimum of the indicated adverse results, requires very careful administration of the course.

In the News

The Engineering Manpower Commission of Engineers Joint Council today announced that its first report on "Utilizing Engineering Manpower" is available. This report, issued as E.M.C. Bulletin No. 1, brings together procedures to be followed in requesting necessary occupational deferments and delays for both reservists and non-reservists (draftees). The Bulletin also includes a brief statement on the problems of both government and industry in selecting and utilizing its technical personnel.

Because of the extreme critical shortage of engineers coupled with an increasing demand for engineers for defense purposes, it is believed that E.M.C. Bulletin No. 1 will be of much value to many employers and users of engineers. Copies may be obtained from Engineering Manpower Commission, 29 West 39th Street, New York 18, New York, at a nominal charge of 25 cents to cover the cost of handling and mailing.

Eleven of the nation's top scientists were named by President Truman to a Science Advisory Committee of the Office of Defense Mobilization, to advise the President and Mobilization Director Charles E. Wilson in matters relating to Scientific Research and development for defense.

Chairman of the group will be Dr. Oliver E. Buckley, who for the last 10 years has been President of Bell Telephone Laboratories, and now becomes Chairman of the Board of Bell Laboratories.

The other members of the committee are: Dr. Detlev W. Bronk, President of Johns Hopkins University and of the National Academy of Sciences; Dr. William Webster, Chairman of the Research and Development Board; Dr. Alan Waterman, Director of the National Science Foundation; Dr. Hugh Dryden, of the Interdepartmental Committee on Scientific Research and Development; Dr. James B. Conant, president of Harvard University; Dr. Lee DuBridge, President of the California Institute of Technology; Dr. James R. Killian, President of the Massachusetts Institute of Technology; Dr. Robert F. Loeb, of the College of Physicians and Surgeons of Columbia University; Dr. J. Robert Oppenheimer, Director and Professor of Physics at the Institute of Advanced Study, Princeton, and Dr. Charles A. Thomas, executive vice president of the Monsanto Chemical Co.

As outlined by President Truman in his letter of invitation to Dr. Buckley, the committee is to be available:

1. "To provide independent advice on scientific matters especially as regards the objectives and interrelations of the several Federal agencies engaged in research of defense significance, including relevant foreign relations and intelligence matters.
2. "To advise on progress being made in dealing with current scientific research problems of defense significance and also concerning defense research matters which need greater attention or emphasis.
3. "To advise concerning plans and methods for the implementation of scientific effort for defense.
4. "For transmitting the views of the scientific community of the country on research and development matters of national defense significance."

The Textbook from the Publisher's Point of View

By E. P. HAMILTON
President, John Wiley & Sons, Inc.

The writing of an engineering or scientific textbook is a major task, as I am sure all authors and publishers fully recognize. The longer I am in this business of publishing, the more I realize this, but nevertheless it is a job worth doing and I hope that I will say nothing to discourage prospective writers.

Before talking about textbooks themselves, it might be appropriate to say something about the function of the publisher. No doubt most teachers, and certainly all authors, have a pretty good idea of the publisher's function, but I have found that there are many people who seem to have little understanding of what a publisher really does. For example, I recall that when I did a good deal of traveling for my firm, salesmen in smoking compartments often asked me what my line was. When I told them publishing, they at once assumed that I was a printer. When I explained that no, we did no printing, they probably reached the conclusion that we were a sort of agent for the printers, or some variety of middleman who later, after the book was published, became a salesman. It is true that a publisher, is among other things, a sort of midleman, but I do not think it hard to convince people that as a middleman he has a useful function to perform.

The publisher is able to assist an author in many ways. In order to make a book useful to a large number of teachers, the publisher brings to the author the benefit of his long experience and often a larger view of the educational scene, as well as current information on courses as given in various institutions, which he gathers from his field men. A book is a costly undertaking, and if it is to yield a fair return to the author and the publisher, it must be so organized as to be suitable for use in a goodly number of colleges.

Wherever possible a publisher likes to work closely with the author in the development of his book as early as he can. Perhaps the author has notes which he is using in his classes; in fact, usually the best books result from such use. If the publisher can see these notes and go over them with his editors and advisers, he can often make suggestions to guide the author in writing a book that will have wide acceptance. On the other hand, tryouts of the sort mentioned above, particularly if continued for several years, can be trying on the student. It is doubtful that a student takes mimeographed notes as seriously as he does a textbook published in regular form. The president of a large state college once remarked to me that in his opinion there were too many mimeographed books in use on his campus. He added that either these notes should be published in book form after a short trial or the author should abandon his notes and find a book that came as near as possible to suiting his needs.

Rather frequently the pubisher may anticipate a need and search out an

* The three papers on textbook planning were presented before the Electrical Engineering Division at the Annual Meeting of the ASEE, Seattle, Washington, June 20, 1950.

author with good background to develop a book. Again, an author may also anticipate a need and write a really pioneering book which may result in courses being developed at other institutions. Unfortunately, with present-day costs this sort of pioneering, however desirable, cannot be encouraged to the same extent as in the so-called "good old days."

Pre-publication Preparation

When the author has his manuscript in final form, a careful editing for uniformity of such details as punctuation, abbreviations, references, etc., is called for. This work is carried on by the publisher. The selection of type, format, and binding is also a function of the publisher. This he does in consultation with the author. The preparation of illustrations also calls for close cooperation and consultation between the author and the publisher.

Finally, after the book is published, it is, of course, the duty of the publishing house to look after all details of advertising, marketing, and distribution. This is a big subject on which I could speak at great length, but it does not appear to me to be especially pertinent to this particular discussion.

I think all his indicates that a publisher has a very important function to perform; in fact, because of his close association with the author, the publication of each book becomes a separate small business, or even sometimes a fairly big business enterprise, in which the author and the publisher are joint partners.

What constitutes a good textbook? Undoubtedly many of you can answer this question better than I. I think, however, that we can all agree that a good textbook must cover adequately and develop logically the subject to be taught. At the same time it must be teachable.

Teachability and Style

Teachability is something not easy of simple definition. It is a combination of many things—clear writing, proper development of the subject matter, clear definitions, good illustrations, together with such aids as worked-out examples, carefully selected problems for solution, and possibly chapter summaries. The organization of a textbook should be such that it can be broken down readily into a group of assignments of appropriate length. This is not always easy to do, as the length of courses may vary, but this practical aspect of teachability should at least be given consideration by the author.

Concerning styles of writing in textbooks, there are as many different styles as there are authors, but anyone through whose hands goes a steady flow of manuscripts, year after year, learns to recognize certain types of writing. Many of the manuscripts that are offered any publisher are in a style that can be called flatly pedestrian. The facts are there, but they are presented without any leavening agent. Such books are like a meal out of cans, eaten from a bare board. The calories and nourishing values may be adequate, but the consumer craves the appetizing qualities that stimulate digestion.

Directly opposed to the pedestrian is a style which could be described as pretentious. I might hesitate to mention this selfconscious style as one that is found in textbooks, but the fact is that it is, and sometimes under distinguished authorship. For example, one well-known author once told me that he was afraid he was thinking more of the impression he wished to make on his professional colleagues than on the student when he wrote his first edition. Again I might cite the comment of a reviewer of a manuscript, who remarked that the author appeared to have one eye on the student reader and the other on the members of his profession. At best the pretentious style is characterized by "gobbledygook"—when the author means "lights must be put out," he says "illumination is required to be extinguished"; at worst this style descends to the ineptly ornate, and the embarrassed reader meets statements about "those fruits upon which the pres-

ent status of network theory rests" or "the dawn of engineering that is slow and ponderous." Such a style has no place in a textbook—not even in the preface to a textbook.

One expects a certain dignity in a book intended for study. Some subject matter, indeed, positively demands a formal presentation. Mathematical subjects, especially, and much of engineering and advanced physics and chemistry, and nearly all statistics can be conveyed mostly by equations and formulations. Chattiness is out of place, if not impossible, in dealing with such material. A bare, functional style is inseparable from the essence of such subjects. Yet even in exploring such rarefied reaches of the mind, some gifted writers can occasionally come down to earth and, still maintaining their dignity and self-respect, adopt a more informal, man-to-man approach. By similes and examples (and even metaphors, as long as they do not become mixed) they can simplify the difficult and make it more readily grasped. This is not as easy as it sounds.

I recall once saying facetiously to Professor William H. Timbie, "Writing of elementary books seems to be easy for you." With characteristic vehemence which I shall not attempt to reproduce he replied that this type of book was the very hardest to write and that he devoted much effort to rewriting and polishing before he was satisfied that he had an understandable result which was at the same time accurate.

The danger in simplification, of course, is that the process may be carried too far and degenerate into the distortions and inaccuracies of the popularizer. When an author breezily brushes aside difficulties and high-handedly pretends that none exist, he is doing his subject an injustice and being unfair to an intelligent reader.

There is no one ideal style. The good writer is full of his subject matter. He sees into it and all around it and can view it in perspective. He is aware of his audience: a specific group, with known background and with definite limitations, whom he had an overwhelming desire to reach and enlighten. He is sufficiently at ease to be himself and flavor his writing with his own personality. Such a man, with the aid and advice of a publisher, should produce something worth-while.

If style is defined as the manner of presentation, the publisher can make some valuable contributions himself. His staff editors can suggest actual changes in writing at the time they are going over the manuscript for editorial details. His production department will select, in consultation with the author, a format and a type which will certainly enhance the author's style, and a proper paper to avoid eyestrain. All these procedures will complement the author's own efforts. Textbooks of twenty or thirty years ago had a noticeable similarity of appearance. Today publishers devote considerable time and talent to making books attractive; they have stimulated the design of new type faces and are using the old ones more effectively. The approach each new manuscript with an open mind, recognizing its individual characteristics and planning a format suitable to its content.

Before leaving the subject of style, something, I think, should be said on nomenclature. Uniformity of nomenclature is highly desirable, as is adherence to the systems prevailing throughout a particular branch of science. We have known books employing nomenclature and terminology in favor among only a minority. It goes without saying that such nomenclature might easily prevent wide acceptance of a book.

Good illustrations are an essential element in a textbook, but they should literally illustrate, not decorate. A well-executed diagram or graph often may be a greater help to understanding than an explanation in words. To be most effective the illustrations should be really integrated with the text. The author who finishes his writing and only then sets out to "collect his figures" will not be

likely to have very good illustrative material.

Services of the Publisher

As all of you know, manufacturers are very willing to help authors in obtaining appropriate copy from which illustrations can be made. Further, engineering departments of the larger companies have offered to aid authors by going over their manuscripts and offering suggestions for changes in line with the latest practice.

Although illustrations are certainly aids to teaching, there are other aids which might be mentioned, for example, worked-out examples, which are often followed by problems for solution or questions, varying in difficulty and numerous enough to permit a teacher to make selections.

The matter of chapter summaries is perhaps a debatable subject. Some teachers maintain that the student should be able to do his own summarizing. On the other hand, summaries can prove very effective in a book, particularly one of a more elementary nature. In addition, good bibliographies, particularly in books of a more advanced character, are certainly called for.

Besides the teaching aids found in textbooks, there are visual aids, which publishers have been considering and even developing in certain fields. My own firm has already issued visual aids in fields other than electrical engineering, and we are now investigating the possibilities of visual aids in that field, not only as supplementary pictorial and graphic material, but also as a means of presenting complicated and involved diagrams and formulas which the instructor must use from day to day. This is a means of saving the lecturer tedious and time-wasting drawing and redrawing. We have followed with interest the experiments of Professor S. G. Lutz and Professor R. G. Kloeffler along this line.

How inclusive should a textbook be? Should it contain material which, although not strictly a part of a course, should add to its value as a reference? Corollary to this is a tendency of some authors to include material which is not actually needed by students but which the author wishes to get into print. Perhaps a moderate amount of such material might be permissible, but if it would add a chapter or two to an already sizeable book, it must be excluded for economic reasons.

Economics of Textbook Publishing

And speaking of economics, perhaps this is as good a place as any to mention that this subject is, I am sure, a disturbing one today to author, teacher, and publisher alike. The cost of producing books has soared in the past eight years and especially in the last five. Just as an example, a few months ago I compared the cost of producing a new edition of a textbook today with its original cost in 1941 and found it to be nearly three times what it was then. Some might ask if in a new edition parts of the old book could be saved. The answer is almost always, no, for the cost of plate alterations is such that one might as well reset. Illustrations can sometimes be re-employed, but even these may have become obsolete and need expensive corrections.

In setting prices for new books and new editions it could be suggested that since everything costs double or more what it did in the prewar period, we charge double for a textbook. Reasonable though this may seem, I am sure that doubling of prices would mean doubling up of students on the purchase of books. We publishers, of course, have had to charge somewhat more for our books than in the prewar era, but not double, certainly, except on specialized books. Temporarily, at least, the situation has been saved by enlarged college enrollments, greater industrial demand, and greater foreign sales, which have permitted larger printings. But, truly, the total outlay for textbooks is a small item in the cost of an engineering education today.

A perfectly natural question to be asked by engineers and scientists is, "What is the publishing industry doing to

lower the high cost of books?" A brief answer, stripped of details, is that research is in progress, some of it sponsored by publishers, and although the results are slow in appearing, expectations are indeed encouraging, esp cially in new methods of type setting.

In conclusion, I hope I have been able to bring you something of the publisher's point of view and what he considers to be the important characteristics of a good textbook. Throughout my talk, I have stressed the importance of quality both in content and in format. To be worth his salt, a publisher must share the high standards of great teachers and must always discourgae careless and mediocre work. By so doing, he should be able to contribute to the development of a strong technical literature.

Commission on Engineering Education

At the request of the Supreme Commander for the Allied Powers, the American Society for Engineering Education and the Unitarian Service Committee, Inc. are jointly organizing a Commission on Engineering Education to visit Japan this summer.

Fifteen Americans, representing the principal areas of engineering education, will leave for the Orient in early July to consult with the Ministry of Education of the Japanese Government, as well as with educators and administrators of engineering colleges in Japan. SCAP has appointed the USC to handle administrative arrangements.

Dr. Harold L. Hazen, Head of the Department of Electrical Engineering at Massachusetts Institute of Technology, is Chairman of the Commission. Miss Dorothy Snavely of New York City, Assistant Director of Medical Projects of the Unitarian Service Committee, will be Executive Officer.

The Commission's itinerary includes Tokyo, Hiroshima, Osaka, Kyoto, Fukuoka, Sendai and Sappora.

Harry P. Hammond, Dean of Engineering at Pennsylvania State College, and Howard L. Brooks, Associate Director of the USC, have organized the Commission.

Persons appointed by the Committee on International Relations of the ASEE to serve on the Commission are: C. W. Beese, Industrial Engineering; A. B. Bronwell, Communications; W. R. Chedsey, Mining Engineering; A. G. Christie, Mechanical Engineering; A. G. H. Dietz, Structural Engineering; B. F. Dodge, Chemical Engineering; H. L. Dodge, Physics; R. B. Finch, Textile Technology; H. L. Hazen, Electrical Engineering; A. L. Miller, Mechanics & Structures; J. A. Sauer, Engineering Mechanics; E. W. Steel, Sanitary Engineering; H. B. Walker, Agricultural Engineering; F. L. Wilkinson, Administration; R. S. Williams, Metallurgy.

Textbook Planning from the Point of View of Teacher and Author

By H. H. SKILLING

Chairman, Department of Electrical Engineering, Stanford University

The general theme of this discussion is the possibility of little better planning of textbooks. To me, that seems to mean that we are discussing something to be done before the book is written. Perhaps it means some kind of guidance to be given the prospective author, with the object of urging him to produce a book that comes close to fitting the needs of his prospective customers. Speaking as one of the customers, that sounds fine. I am not sure just how it is to be done. But let us examine how the customers, and how the authors, operate at present, and see what seems to be possible.

We, who are teachers, know what we want when we select a textbook. We don't all want quite the same thing, fortunately, but I suppose the one fundamental need that everyone will agree on is that he wants a book to fit the course he is teaching.

How do you choose a book? When you teach a course, do you adapt your presentation to fit the best available book, or do you require the textbook to match your method of presentation or do you use books for reference only?

Speaking as a typical teacher I might say that it is my personal preference, at least for undergraduate courses, to adopt a good book and make the course fit the book. There are problems in fitting a course to an available book, but there are worse problems in establishing a course, deciding just how it is to be taught, and then trying to select a book to fit the course, and the biggest difficulty is that you generally can't find such a book.

What do you do then? Obviously, you write a book. It is a fine way, but rather laborious. It was this business, I think, of writing books to keep the courses going that the Preacher in Ecclesiastes has in mind when he said: "Of making many books there is no end; and much study is a weariness of the flesh" (Eccl. xii, 12).

If you are like me, and are willing to adapt a course to a good book, it seems that there is some hope for the idea of attempting to influence authors to write books the way we teachers want them. All that is needed is to find, somehow, a large enough group of teachers, all of whom want a book of about the same kind, within limits of the teachers' adaptability. The needs and desires of this group of teachers are then conveyed, how I don't know, to people interested in writing a book of this nature. Perhaps one or more good manuscripts will result from this process.

But there are several rather difficult problems, and the worst problems all revolve about this question: is it likely that a group of teachers can specify what they want in a way to result in excellent textbooks?

Suppose a group of teachers of electronics, for instance, get together and decide they want a book written according to a certain plan. Someone starts working on it, and in three or four years the book appears on the market. Now: (1) do the teachers still want it, or have they changed their minds, influenced either by trends in teaching or changes in the sub-

ject matter of electronics; and (2) is it possible that an independent author, more brilliant or more inspired than the group of teachers, or perhaps just giving a greater share of his time to thinking about it, may come through in the meantime with a better book—a book that even the teachers themselves will agree is better than what they asked for?

What Motivates the Author?

Speaking of authors brings in the other side of my dual subject—the point of view of the authors. If you go to a prospective author and say: "This is the kind of book that the customers want," will he write it, and do a good job?

Why do authors write books, anyway? We seem to need to know what motivates an author before we can decide what we can get him to do for us. What is it that makes a man undertake this "weariness of the flesh" that the Preacher speaks so feelingly about?

One reason I have already mentioned: you, as a teacher, want a book to fit a course you teach, and the only way to get a satisfactory book is to write one yourself.

Then some write for money, and happily the arrangements under which textbooks are printed are such that a very respectable amount of cash rolls in to reward a man who has produced the kind of book that we teachers need. It is common enough to hear slighting remarks about the lack of financial return from a published book, but this is sheer swank. Books that sell do pay.

Then there are those who write for reputation. Some write for a scholarly reputation, and some for a general public reputation. Erasmus knew about these people when he wrote, "The Praise of Folly" four and a half centuries ago. He said—or, rather, he made Folly say, "The ones who write learnedly, for the verdict of a few scholars, seem to me more pitiable than happy, since they continually torture themselves: they add, they alter, they blot something out, they put it back in, they do their work over, they recast it, they show it to their friends, they keep it for nine years; yet they never satisfy themselves. As such a price they buy praise—and that the praise of a handful. They buy it with so much loss of that sweetest of all things, sleep, so much sweat, so many vexations. Add also the loss of health, the wreck of their good looks, weakness of eyes or even blindness, poverty, malice, denial of pleasures, premature old age, and early death. The scholar considers himself compensated for such ills when he wins the approbation of one or two other weak-eyed scholars."

This speech, you will understand, is from the mouth of Folly, who is not to be taken seriously. She thinks more highly, she says, of "those who blacken paper with sheer triviality. . . . For these are crazy in a far happier way. It is worth one's while to see how pleased authors are with themselves when they are popular, and pointed out in a crowd." And though this speech may be by Folly, and written a hundred years before Shakespeare's day, it still paints two perfectly valid reasons for the writing that is being done today: professional reputation, and common fame. We all love it. And a variant of this is the more local prestige that an author gains with his Dean and with the President of his own college. As Lord Byron said, "'Tis pleasant, sure, to see one's name in print; a book's a book, although there's nothing in't."

One of the rewards of authorship is that publicaton carries our words to so wide an audience. Every author, I think, is happy that his ideas may reach a thousand pairs of eyes, through publication, where they could reach only ten pairs of ears in lectures. Some have the greater glory of seeing their thoughts, in print they cannot themselves read, going to teach students in countries that they themselves will never see.

And to this spread of a man's influence over the face of the carth, publication even adds a certain degree of im-

mortality. Perhaps his work will live on. Some authors' do. Don't you sometimes feel, as I do, better acquainted with an author who is long since dead than with some of your associates among the living? To a good many authors, it is no small matter that their teaching will continue after they, themselves, have vanished. Edward Gibbon wrote his famous "Decline and Fall of the Roman Empire" with the expectation, he says, that it might "perhaps, a hundred years hence still continue to be abused," and he was modest, for it has now been 175 years, and it is still being abused. "In old age," he says, "the consolation of hope is reserved for . . . the vanity of authors who presume the immortality of their name and writings." And Henry Fielding hoped "to be read with honor by those who never knew nor saw me, and whom I shall neither know nor see."

Then there are those who write for the sheer pleasure of writing. Where some men play chess, and some solve cross-word puzzles, other take pleasure in finding the exactly right expression of their ideas. The choice of the right phrase, the dove-tailing of ideas, brings delight. Do you know the verse from an author in a Carinthian monastery of a thousand years ago that starts like this: "I and Pangar Ban my cat, 'tis a like task we are at: hunting mice is his delight; hunting words I sit all night."

Finally, some authors write to promote an idea or an individual interest of their own; to convert readers to their own belief or point of view. It is not necessary to look to politics for examples of this. I know from my publishing friends that many an author tries to use his book as a sounding board for his hobby. Indeed, it would be rude of me to mention the examples I can think of in half the books I know. I believe it is rather an unusual author of a textbook who does not give some unjustified space to a method because it is his method, or to the results of research because it is his research, or to an argument because he wants to proselyte—not to teach.

Motivation and Results

That makes six or seven reasons for writing textbooks. These may not be all the reasons for which authors write, but they are enough. And the question is this: will these motives act to make an author write the kind of book we think he ought to write, to fit the purposes that we propose? Let us review them.

1. If you write for your own classes. your book may be shaped to fit a general need if your class is a typical class. On the other hand, it must not be forgotten that many of the most important books come out of classes that are pioneering in a new presentation, and nobody can guide the author.

2. If you write for money, naturally a plan that will increase your sales will be heartily welcome.

3. If you write for fame and public reputation, you will be pleased with a plan that will make your book more widely read.

4. But if you write for recognition among the learned of your own profession, your ideas of what your book should contain will not be open to much persuasion.

5. If your pleasure is in extending your influence to a wide family of students, extending over the world and continuing through the years, you want a book that will be beneficial to many readers—yet, at the same time, you want it to be personally and individually yours.

6. The man who writes for the simple pleasure of writing will not care to be restricted by any such guidance, and

7. The writer who has a cause to support or a hobby to ride will lose interest if he is restricted; if his favorite topics were sheared back, as I suppose they would have to be, he would find that his salt had lost its savor.

Now the fact is, of course, that every man who writes a book is motivated by several if not all of these seven factors. The public and the publishers might not be sorry to lose an author motivated all

by one or all by another, but if you discourage all authors who like to see their names in print, or who like money or who have a hobby, there would be a dearth of books.

Perhaps it is safe to draw conclusions to this extent. First, is planning desirable? Planning based on the desires of teachers would be helpful in some ways. It could prevent an author from making a mistake about the actual demand for a book of a certain type. It could indicate preference regarding the less personal characteristics of the book: how long a book is acceptable; how many problems are wanted; what system of units is most popular; is it convenient that the notation agree with that of some other book? On the other hand, planning is dangerous if there is any tendency for it to stifle originality of ideas. Is there such a danger?

Second, is planning possible? Planning must operate on the author, and the question is: how will the good, bad, and indifferent authors react to it? Some of the authors' motives will respond to suggestion—some will resist. Will the good, bad, and indifferent authors respond in such a way that books will be better, planned than unplanned? I don't know the answer to that one. I have run out of conclusions, and I think I should like to leave these questions up to you.

Textbook Planning from the Point of View of Author and Editor

By W. L. EVERITT
Dean of Engineering, University of Illinois

As th size and complexity of any enterprise increases, planning becomes more and more important. This is necessary in all cooperative efforts, and engineering education is recognized as such a cooperative effort. While we may subscribe to the idea that Mark Hopkins on one end of a log and a student on the other would be the important elements of a university for a general education, modern technical education requires the utilization of many more facilities and aids. Nevertheless, we must continue to recognize that the character, ability and background of the teacher is *the* most important consideration.

In these days of emphasis on visual aids, let us remember that the most important, highly developed, and economical visual aids are books. They are a necessary part of the instructional system at the school and university level. How ever, if we accept the idea that the most important purpose of formal education is not to teach facts, but to develop in the student a confidence in his ability to learn and a method for continued development as he meets new situations, then we must prepare hin. to depend upon books in his post-school years for a lifetime of learning and vision. It is evident, therefore, that technical books should. and I believe do, serve a dual purpose:

1. as textbooks for residence courses where the material may be supplemented and developed by an instructor and
2. as reference books for self education.

It is true, however, that no typical individual exists who could speak in a representative manner for his group. It is in that very divergence of readers that the difficulty of satisfactory planning and coordination for the publication of textbooks lies. Any such planning which may be attempted will necessarily involve approximations and personal judgments. For the purpose of developing additional judgment and coordination, many publishers are making more and more use of technical consulting editors for definite but fairly broad fields, and it is this area area of planning that I was asked to represent on this panel.

Technical Area Conferences to Aid Authors

At times the need for the development of a new technical area by both courses and books becomes quite evident to a number of people. Under these conditions it may be possible to call a conference where representative outlines for a course may be worked out. Following such a conference, it is almost inevitable that one or more books will appear based upon the plans which were developed. Good examples of this occurred during the war. In the fall of 1941, a large group of us met at M. I. T. for a three weeks session to discuss the needs for instruction at the college senior level for Electrical Engineers on the principles of Ultra High Frequencies, as needed for the growing applications of radar. A surprising unanimity was attained in the development of course outlines and a supporting program of laboratory work. This immediately developed a need for a textbook, which in turn was justified

economically. The well-known book on Ultra-High-Frequency Techniques by Brainerd, Koehler, Reich and Woodruff resulted. In the winter of 1942 similar planning and development resulted in recognition of the need for the E.S.M.W.T. courses on Fundamentals of Radio. Several new books appeared to compete for this market. The series brought out by the Electrical Engineering Department at M. I. T. is another example of effective planning by the committee method to meet a definite objective.

Under ordinary conditions this committee procedure is only occasionally practical. There is not usually an unanimity on what is needed, there may not exist a definite sponsoring agency. and frankly, there would be difficulties in preparing a program that would avoid the dangers associated with the existence of financial and professional interests of authors, publishers and teachers. However, from time to time, as new areas of interest develop, for example, servomechanisms, or electronics for nonelectrical engineers, it might be well for this society or this section to consider setting up conferences to plan programs for appropriate courses. Such conferences might meet after or during the summer meeting of the society. As courses are developed, textbooks would not be long in appearing. In a free enterprise system I do not think it would be desirable for the sponsoring agency to designate the specific authors.

Spontanaity of Textbook Authorship

Becoming the author of a book is a spontaneous process. It is important that no planning process should hamper this spontaneity or the results will be drab and colorless. It is doubtful if many good books are produced by assignment. This is illustrated by the difficulty, especially during the war, of getting good technical manuals on manufactured equipment. Such manuals must be written, perhaps they are part of a contract, so someone is directed to write them. Even though the authors may be professionals, the resultant output is generally considered mediocre.

Since an author is self driven, he usually has a message, something he wants to tell the world about. I think this is desirable. It provides the sparkle that differentiates the interesting from the dull. The greater number of electrical engineering books are produced because the author is a teacher in fact or at heart who believes firmly that he can plan a course on, and tell his student more clearly about, his subject then anybody else. Hence, he starts to prepare a set of mimeograph notes to supplement the inadequacies he believes exist in available texts. These he may ultimately develop into a full fledged text. I believe this experimental process is a good one if the author really receives recognizes, accepts, and acts on the criticisms which this makes available. This criticism may appear in a number of forms. It may come from suggestions from students, from comments of colleagues using the material, or it may be in the form of the low grades of a class which has been examined on the material which the manuscript has been designed to elucidate.

Author's Responsibility

In the development of all human relationships the ability to put oneself in the other fellows place is one of the most important attributes. It is particularly important for the teacher to analyze his teaching from the standpoint of the student, for the author from the position of the reader. But it is technically difficult for an author to do this, the mere act of going over and over the manuscript, a necessary part of writing, makes it almost impossible not to overlook inadequacies in presentation. It is at this point that the technical editor may perform an important function. He should try to read the manuscript as though he were a student with only the preparation which the manuscript assumes. He must be watchful that the presentation is logical, and develops the subject smoothly without sudden changes in dif-

ficulty, and without requirements of supplementary knowledge which cannot be expected from the reader. He should recognize lack of clarity and call for improvements where needed.

New books should be really new and not a rehash of old material. It is true that the new part may be largely a new method of organization or presentation, but unless there is a real indication of originality I think there is a moral if not a legal responsibility on the author, editor and publisher not to develop a book just to introduce a name to the public. Some technical books have skated pretty close to plagiarism even if it could not be proven in court.

It is probable that this panel would not have been developed unless a need were felt for more voice in the production of books by the teacher. I have suggested the possibility of special conferences from time to time. I believe the development of the series idea provides an additional avenue for teachers to indicate to series editors what they want. This can be done by personal discussion or by correspondence. I can say that such suggestions would be welcomed, and I believe would produce desirable results. Series editors are individuals in your general field who can work with you in a personal manner. They in turn will have contacts with prospective and developing authors and can act as exchange centers.

It is hoped that this panel discussion will be a step forward in the planning of technical books. At the same time it should be recognized that we are the envy of the world not only on our technical developments, but also in the manner in which we have reduced those developments to the printed work so that they may be passed on to students, in both school and industry, and not only in the United States, but wherever the English language is read.

College Notes

Dr. Harry P. Hammond, dean of the School of Engineering at the **Pennsylvania State College,** will retire with emeritus rank on Sept. 1 and will be succeeded by Dr. Eric A. Walker, director of the Ordnance Research Laboratory and professor and head of the department of electrical engineering. The change was announced by Dr. Milton S. Eisenhower, president of the College. Dr. Walker, came to Penn State on July 1, 1945, from Harvard Underwater Sound Laboratory. For the past year, Dr. Walker has been on a leave of absence, acting as executive secretary of the Research and Development Board of the Department of Defense.

The Economic Advancement of Underdeveloped Areas[1]

By YALE BROZEN

Professor of Economics, Northwestern University

There is deep concern in the world today over the problem of underdeveloped areas. The "problem" is a different one, depending on who defines it, but the common aspect of all the different "problems" is the low level of per capita income in these areas. The United Nations report on *Technical Assistance for Economic Development* implies that the underdeveloped territories are those where resides "substantially more than half the world's population" and where average income per head is "less (often much less) than $100 per year" in contrast with an average income in the United States in 1947 of $1400.

The average per capita income in an area may be raised by action along three different lines. One is a reduction of the population (by birth control or by increase of the death rate or emigration in those classes of the population which have little productive capacity) relative to non-transportable resources, if industry and agriculture are not operating in the range of increasing average returns. A second line is through an increase in resources relative to the population (by importation or accumulation of capital). The third line is through improvements in the average technology practiced.

These measures increase the kind of income that can be measured against money—the usual statistical concept of income. An ever present danger in development programs is that the sacrifice of psychic income from non-pecuniary sources may exceed the gain in psychic income resulting from the increased production of the goods which bring pecuniary returns. The production of transferable goods (those that can be bought and sold) may increase at the expense of the production of non-transferable goods (love, stability, personal integration, etc.).

The Technological Level of Backward Areas

The Point Four program is aimed at the problem of raising the average level of technology practiced in underdeveloped areas. Average technology lags behind technological leaders who in turn lag behind technological possibilities. That these lags are greater than those dictated by economic considerations is not at all certain.[2] Usually, naive comparisons of average productivity per head in less developed regions with that in highly-developed regions are used to show what technology can do. This fails to take account, however, of the difference in resource patterns and, also, confuses the problem of technological advance with the problem of the capital supply.

[1] This paper was made possible by grants from the Rockefeller Foundation and the Technological Institute at Northwestern University. An expanded version will appear as a chapter in *The Economics of Technological Change* which will be published in 1952.

[2] See Yale Brozen, *Social Implications of Technological Change* (available on request from the Social Science Research Council, 230 Park Ave., New York 17, New York), Ch. 6 for a discussion of the distinctions between levels of technology and the lags dictated by economic considerations.

Even if capital were supplied on the same conditions as in highly developed areas, earnings possibilities may be inadequate to attract a sufficient supply of capital to raise the amount per head to the level prevailing in other areas. Aside from the question of the supply of labor skills or the institutional structure, the lack of earning prospects may be the consequence of the resource pattern. Technologies developed for an oil-coal-iron-waterpower-broadleaf-forest complex of resources are not easily transferable to tropical rain forest or semi-arid regions in which the primary source of power is wind and sun. Technological possibilities for such areas may be very low.

Rather than simply transfer our tools and techniques to the world's backward areas, a more economic procedure might be the development of an appropriate technology for those areas. A research and development program such as that which produced the designs for buses and trucks now used for desert runs in the Near East, together with the necessary new equipment, might be less costly than building a railroad. Such a program might make progress economically feasible where, with present techniques, it would be uneconomic.

Directions for research programs designed to raise the level of technological possibilities must be carefully chosen in terms of both the economic results that may flow from new techniques and the value consequences. If an area is the major producer of an internationally traded commodity for which demand is inelastic and to which its resources are specialized, improvement in output from given quantities of resources will cause the terms of trade to move very adversely with small increases in the rate of production. As a consequence, area income will fall. In these circumstances, research should be directed toward the development of alternative uses for the resources of the area rather than the improvement of present uses.

The value consequences of changed techniques of production must also be considered. If natives of an area prefer the values inherent in cottage industry to those inherent in factory industry, for example, research should be directed toward the improvement of techniques of cottage production.

The values inherent in cottage production of textiles have been recognized in legislation. The Province of Madras, India, prohibits the further expansion of textile mills. Such action has been undertaken because the values inherent in cottage industry are deemed to outweigh the value of extra product obtainable by reorganizing the industry along factory lines.

Appropriate Techniques and Industries for Under-Developed Regions

The selection of techniques to be used and industries to be developed in a region must be governed by the resource and market patterns of the area. If large amounts of capital are required to practice soil conserving farming, then such farming technique should not be practiced in regions with abundant soil and scarce capital.

Resource patterns of underdeveloped regions do not fall into any one type. Generally, the regions into which European immigrants poured were underpopulated with the consequence that land intensive techniques and industries were appropriate. Usually, capital was scarce in such regions, as well as manpower, which precluded capital intensive industry until much later stages of development when an indigenous capital supply began to accumulate to add to foreign sources. Technological possibilities were developed in the direction of both labor and capital-saving devices.

Many of the areas which concern us today have high population densities. Here, the appropriate techniques and industries are those which use much labor and relatively little land or capital. Where the skill of the labor force is low, the feasible techniques are those which require little skill intensity.

By introducing industry with a low skill requirement, the skill level of a labor force may be raised in the process of learning the low level skill required. This may be more economical than attempting to raise labor skill to the level required for a machine tool industry by the more direct means of a sufficiently long training period. By starting a textile industry, skill and textiles are produced as joint products at a cost lower than that of producing them separately.

The textile industry has been the great educator in industrial skills. It has typically developed in regions possessing little factory industry. In it, labor learned the requisite discipline and skills which then became a part of the environment. Industry using higher level skills could then develop, taking labor which had grown up in such an environment and educating it to a higher level as easily as the textile industry had educated it to a low level.

In regions where textile mills had been long established, industries requiring higher skills usually began bidding labor away from the textile mills. Costs of producing textiles in such regions rose, insofar as growth of skill did not succeed in encouraging the use of skill-intensive techniques in producing textiles. As costs went up, new regions possessing supplies of low skill labor found it economic to establish a textile industry. In the United States, for example, the textile mills of New England succumbed to the combined onslaught of the competition for its labor by the more skill-intensive industries and the competition for its markets by the new mills of the Carolina Piedmont. The Piedmont is suffering a similar fate as the mills of Mississippi grow.

It is not easy to judge what industry will be appropriate for an underdeveloped area by examining the resource combinations of those operating in better developed areas. Farming in the United States is capital and land intensive. This does not necessarily mean that farming is precluded in areas lacking capital and poor in land. Other techniques may be available which are not intensive in the scarce resources. Farm operation in some sections of the world uses techniques involving extreme labor intensity and very little capital and land. The little capital and land available is intensively worked and little of it is used per unit of product.

With techniques of this latter type, we would expect high yields per acre, although yields per man would be low. Yet, we sometimes find areas of scarce land are also areas of low yield relative to the yields in the United States and Europe. Here, it would seem, is a place where great improvements can easily be made by a change in practice with little addition of resources. By changing the strain used, crop yields may be increased. It is conservatively estimated that yields in the rice-producing countries could be increased by 10 per cent if the best varieties were generally utilized, while the introduction of hybrid varieties of corn can add 20 or 30 per cent to the crops. Some changes, such as fertilization and irrigation, may require additional capital. We might expect the additional capital to be extremely productive in these circumstances. Development in these cases requires, then, an increased capital supply, or at least diversion from other uses, as well as a rise in the average level of technology.

In almost every practical case, the problem of development involves a need for more capital if the better technique is to be put into operation. Since capital from abroad seldom amounts to more than a dribble, most areas must look to means of supplying their own capital. Essentially, this means they must either find ways to release resources from subsistence requirements or find ways of reducing consumption, assuming there are no large supplies invested in stores of value as in India.

A most fruitful method of acquiring resources for use in capital construction is that of raising the health of the population and releasing the millions of man-

days lost through illness. A dose of DDT costing little may produce man-days released from malarial confinements worth much. Water purification and sanitation measures may be similarly productive.

The underdeveloped area in the modern world need not concern itself with developing industry according to the priority of wants as long as interregional commodity flows are not barred. For it, resource patterns, technology, and markets are the appropriate determinants of its growth. It is more efficient to engage in a land-intensive industry such as iron ore mining in an underpopulated area like Labrador than it is to grow food. Foodstuffs can be obtained with less expenditure of resources, under the pattern of available techniques, by mining ore and trading with other areas. Food production may be increased, then, by ceasing its direct production.

Similarly, a backward area can develop a capital-intensive industry when it can compete with capital-rich industries of other areas for its capital rather than with capital-poor industries in its own area. To the extent that capital markets are imperfect, or that political or monetary instability or property insecurity prevails, this does not apply.

Finally, the sequence of industries and techniques used during a course of development will depend upon the relationship of external economies. As long as transport is crude, small-scale operations appropriate to a local market will prevail. The building of a bridge may connect markets (as in a recent instance in Liberia) and permit the growth of specialization and of large scale, capital-intensive industry. The state of development of services such as transport, electric power, water supply, etc. is both consequence and determinant of industrial development.

As industry grows in an area, individual concerns can shed functions to their gain and contribute to the founding of separate and new industries which in turn may make further industrialization possible. As the fishing industry in tropical Monrovia grows, it may finally produce enough fish to supply immediate needs with enough left over to be quick-frozen for off-seasons and other markets. A refrigeration plant may then become economic, but it will have to produce its own power. Perhaps diesel or gasoline-engine driven compressors will serve it. As other concerns begin production, it may finally become economic to found a central electric power plant. The resultant cheapening of power may then lead to manufacturing or other operations which could not be undertaken if expensive self-produced power had to be used. A priority in the development of industry may be dictated, then, with those consuming little power or using an abundant domestic resource coming first. Those consuming much power without any offset through economies generated by use of an abundant local resource must wait until the advantage of external economies in the production of power makes their operation economic.

We have here three primary determinants of the developmental pattern. Resource oriented industries which can capitalize on some resource relatively more abundant in the area, and market oriented industries for whose produce a local market exists, are one element in the pattern. The second element in the pattern is the barriers between the area in question and others. High barriers dictate that priority of wants and local supplies of the kinds of resources (capital and skilled labor) that might otherwise immigrate must rule the developmental pattern. If no barriers exist, then only the non-transferable resources and transportation economies in supplying the local market, that is, the first set of determinants, will dominate. Finally, the time sequence of the developmental pattern is important. Industry using low level skills and suffering little from the lack of external economies should be founded first. Industries using high level skills and dependent on external economies can then follow.

False Issues in Development of Backward Areas

In the opening paragraphs, we warned against the application of Western standards to low income areas in judging whether or not a developmental program should be instituted. A society in which men prefer planting their sweet potatoes in a neighbor's field in order to have the pleasure of companionship is not to be lightly regarded as suffering from a lack of indoor plumbing. If leisure and aimless camaraderie are preferred to variety in adornment, frequent baths, and gasoline powered vehicles, then a proper measure of income may indicate a higher level per capita than that prevailing in "advanced" regions.

Many of the programs proposed for less-developed areas emphasize industrialization as a goal. The resource patterns found in some regions, however, will yield higher per capita incomes if used in agricultural pursuits or other non-industrial uses. The yearning for industrialization is rational for these areas only if we presume that their populations want to prepare for war or if this is the only method of inculcating new attitudes toward marriage and family size which will have desired effects on population density.

Even where industrialization is appropriate, there is often an unwarranted eagerness to develop heavy, large-scale industries. Industries such as steel, for example, are the late comers in any sequence of industrialization. Unless a large market, on the order of an annual demand for half-a-million tons, is available, and unless men skilled in organization have been trained and have a background of experience, a steel industry will prove uneconomic although all the necessary limestone, coal and ore may be present. For a balanced steel industry, a three million ton market is required. Respect must be paid to the necessity of following the sequences discussed above in industrializing an area.

If economic development requires the building up of extractive industries such as mining and lumbering, the cry is often raised that the area is exploited. Materials are being removed, is the complaint, that should be kept as a basis for domestic industry. Aside from any conservation issue, the deposit or timber stand involved simply represents a certain amount of capital in a specific form. If the natives of any area are able to convert this capital into other forms by selling the specific capital items, they will be able to obtain other kinds of capital embodied in the form of trucks, pumps, tools, and similar items which can contribute more to increasing the productivity of their labor than idle capital in the form of undeveloped natural resources. If the native population chooses to dissave, that is, to use the proceeds from the sale of capital items to increase their consumption, this surely is a decision they are entitled to make.

Usually, the question of exploitation can be validly raised only when land tenure systems are such as to permit foreigners to dispossess native owners without adequate compensation for the property involved. The charge of such action can be leveled with merit against many colonial administrations. This, however, is a question of property rights rather than a question of the type of industry appropriate for the region in question.

In some areas, there is a fear that permitting foreigners to withdraw the earnings on their capital is exploitative. Investment by foreigners increases production. The private returns to foreign investors will be less than the increase in production. By permitting withdrawal of profits, natives will find that investment will be made by foreigners that would otherwise be blocked, and that native living standards will rise since even complete withdrawal of private earnings by foreigners will leave the area economy with a net increase in supplies of goods This will be true, if for no other reasons, because natives will not

take jobs in enterprises started by foreigners unless the jobs pay as well as or better than those they leave, assuming no preferential treatment is used to force natives into such position (such as the head tax and hut tax widely used in Africa).

The capital supply is a problem often raised in discussions of area development. It is absurd to presume that the United States can supply more than a dribble of capital to other areas. The five billion dollar a year Marshall Plan was only a drop in the European bucket, largely useful as an incentive to Europeans to re-order their economy, yet it was one of the causes of inflationary pressure in the United States. In the total world situation the few billions the United States can afford each year can do little more than provide for technological leaders.

Native capital must furnish the long run base for development programs. At present, much of the native capital that might be available is grossly misdirected because social institutions inhibit productive use of it. Natives who might devise or institute new techniques, develop enterprises, or furnish the capital for such projects fail to do so because of arbitrary tax laws, discriminatory procedures used by colonial administrations, indefinite property tenure systems, leases which afford no motivation for economic use of land, lack of knowledge of possibilities, political arrangements such that the return to efforts directed toward obtaining power is greater than the return to developmental efforts, and a host of related reasons.

Another issue raised in connection with the role of the United States is the effect of development abroad on the U. S. economy and the living standards of its workers. If foreign industry develops with the use of low-paid labor, will we not have to raise our tariff barriers or suffer lower living standards? Any elementary economics textbook can answer this question and does answer it with an emphatic "No!" By wiping out the involved, cumbersome U. S. customs procedures and permitting free entry of goods, we can aid development in the underdeveloped areas and *raise* our living standards. Our workers will find relatively more productive job opportunities opening up for them and the international division of labor will increase world production with the consequence that there will be more goods for U. S. nationals as well as for foreigners. Foreign living standards will rise, but not at our expense. Our living standards will rise as well.

Finally, we must warn again against judging the appropriateness of an industry for a particular area by the form of its technical organization in a developed area. Modern textile industry in advanced areas uses large quantities of capital and little unskilled labor. Despite the lack of capital and abundance of unskilled labor in less-developed sections, it may pay to introduce textile industry. The techniques employed, however, should not be those common to advanced areas but, instead, those which make use of the resources abundant in the area in question and minimize the use of its scarce resources. American engineers aiding such developments will be less often accused of uneconomic "over-design" of installations if they stop slavishly imitating the techniques they have seen used in their own country.

Engineering Norms for the Iowa Chemistry Aptitude Test, Form M

By WILLIAM C. KRATHWOHL
Director of Tests, Institute for Psychological Services, Illinois Institute of Technology

In the manual for the Iowa Placement Examinations, Form M, separate sets of norms are given for engineering and liberal arts students for the mathematics and physics aptitude tests, but only one set of general norms is given for the chemistry aptitude test. Since the mathematics and physics aptitude norms for engineering students differ markedly from those for liberal arts students, it was felt that there might also be a similar difference for the chemistry aptitude test. Such has been found to be the case in this instance. These norms for engineering students should be particularly valuable to high school counselors for use with students who plan to enter the engineering profession.

TABLE I

ENTERING FRESHMAN ENGINEERING STUDENT NORMS FOR THE IOWA CHEMISTRY APTITUDE TEST, FORM M

Percentile Ranks	Raw Scores	Percentile Ranks	Raw Scores
99	122	50	95
95	117	45	92
90	113	40	90
85	109	35	88
80	107	30	86
75	104	25	83
70	102	20	80
65	100	15	77
60	98	10	73
55	97	5	63
		1	46

The norms for the Iowa Chemistry Aptitude Test, Form M which are given here for entering engineering students are based on 675 engineering students at the Illinois Institute of Technology, who entered between September 1948 and February 1950 and who had complete records. These 675 students are classified into the following engineering groups: 222 mechanical, 203 electrical, 136 chemical and metallurgical, 82 civil and 32 industrial.

The chemistry aptitude norms for these students are contained in Table I.

The statistical constants for these norms are: mean $= 92.8$, sigma $= 15.6$, and median $= 94.6$.

In order to get an idea of the kind of students who constitute this group, statistical constants for them are given in Table II, for the 1945 edition of the American Council on Education Psychological Examination, and also for the Bennett-Fry Test of Mechanical Comprehension, Form BB. The psychological examination was used to indicate something of the mental ability of the students being tested, and the mechanical comprehension test was used to compare the entering freshmen group with the group who entered with advanced standing.

These scores give evidence that the group has some of the typical characteristics of engineering students. For instance, the mean of their total scores is higher than that of the average liberal arts student and likewise their performance on the Q parts of the test is much

higher than on the L sections. The mechanical comprehension data show that the group, as far as this test is concerned, is typical of engineering freshmen.

Norms on the Iowa Chemistry Aptitude Test, Form M, for engineering students who entered with advanced standing, are given for two reasons. (1) Students entering with advanced standing should have a higher performance on an aptitude test than do freshmen, because there is a certain amount of learning connected with most written aptitude tests, and because most students with advanced standing have already undergone a screening effect in their freshmen year which eliminates the less able students. (2) Admission officers nowadays are faced with the problem of admitting more students with advanced standing in comparison with freshmen than they formerly did. This problem has arisen because of the increased number of junior colleges which, with comparatively lower tuition fees, attract students to complete one or two years at those schools before entering the technical college of their final choice.

Table III gives the norms for the Iowa Chemistry Aptitude Test, Form M for advanced engineering students. These norms are based on 532 students who entered the Illinois Institute of Technology with advanced credits and who had complete records between September 1948 and February 1950. The students are classified into the following engineering groups: 169 mechanical, 160 electrical, 84 chemical and metallurgical, 63 civil, and 56 industrial.

TABLE III

Advanced Engineering Student Norms for the Iowa Chemistry Aptitude Test, Form M

Percentile Ranks	Raw Scores	Percentile Ranks	Raw Scores
99	127	50	107
95	122	45	106
90	120	40	105
85	118	35	103
80	117	30	101
75	115	25	98
70	113	20	96
65	112	15	93
60	110	10	89
55	109	5	83
		1	73

The statistical constants for these norms are: mean $= 105.9$, sigma $= 12.1$, and median $= 107.4$.

In order to get an idea of the kind of students who constitute this group, statistical constants for them are given in Table IV for the Ohio Psychological Examination, Form 22, the Iowa Physics Aptitude Test, Form M, and the Bennett-Fry Test of Mechanical Comprehension, Form BB.

The fact that the national percentile rank on the Ohio Psychological Examination is not higher than 51 is probably due

TABLE II

Statistical Constants for the Entering Freshman Group

Tests	Mean	Sigma	Median	Percentile Equivalent	For Comparison Group
A.C.E. Psychological Examination					
Total Score	118.9	19.2	118.7	75	College Freshman
L Score	69.0	14.3	68.9	65	College Freshman
Q Score	49.7	8.2	49.9	84	College Freshman
Bennett Mechanical Comprehension—BB	37.5	10.0	38.2	46	Engineering Freshman

TABLE IV

STATISTICAL CONSTANTS FOR THE ADVANCED STANDING GROUP

	Mean	Sigma	Median	Percentile Equivalent	For Comparison Group
Ohio Psychological Examination, Form 22	90.0	22.1	89.2	51	College Freshman
Iowa Physics Aptitude, M	65.2	11.1	64.9	60	Engineering Freshman
Bennett Mechanical Comprehension, Form BB	41.3	9.1	42.3	62	Engineering Freshman

to the verbal nature of this test. Engineering students seldom do as well on verbal tests as they do on tests involving quantitative or abstract material.

As was expected, the percentile ranks for the medians for the Physics Aptitude Test and the Mechanical Comprehension Test are above those for entering freshmen.

The mean percentile rank on the Mechanical Comprehension Test for advanced students is higher than that for the entering freshmen, probably because of the screening effect of the first year or two in an engineering school.

In order to discover the degree of advancement of these students, an average was found of the highest course in mathematics which had been offered for entrance. If college algebra is counted as 1, analytical geometry as 2, differential calculus as 3, integral calculus as 4, and differential equations as 5, the average highest course was found to be 3.01. This number shows that the average advanced student has had at least differential calculus before entering, which places the average of the group at not less than the middle of the sophomore year. Just how much more advanced the average of the group is cannot be estimated from this data, since there usually is no required mathematics for the junior and senior year.

It is hoped that the use of these norms will be of help to counselors and advisors in giving a clearer picture of the chemistry aptitude of an engineering student than if such a student were compared with a group of general freshmen.

An inspection of the national percentiles of the medians for the various tests indicates the necessity for differentiating between engineering students and students in general. It also suggests the advisability of establishing norms for different years in an engineering school. Such a set of norms should prove to be useful, particularly in our present state of national emergency.

College Notes

President Dawson was honored by receiving the Doctor of Engineering Degree, Honoris Causae, from the University of Syracuse and Nova Scotia Technical College. He delivered the principal address at the anniversary celebration of the L. C. Smith School of Applied Science at Syracuse University and also at the graduation of the Nova Scotia Technical College. Throughout the year, President Dawson has visited many of the ASEE Section Meetings, including those of the Southwestern Section, the Rocky Mountain Section, the North Mid-West Section, the Michigan Section, and the Missouri Section. He has also attended meetings of the ECPD, the Division of Relations With Industry, and other group meetings involving ASEE participation.

Photoelasticity: A Powerful Educational Tool

By EVERETT CHAPMAN
Consulting Engineer, West Chester, Pennsylvania

Photoelasticity, as an educational tool, has several strong appeals.

It is an exact method. Certain materials exhibit double refraction when strained and the theory has a mathematically exact correspondence with the elastic theory of stress distribution. Thus, the method will quantitatively check the results of simple analysis and will reach far beyond into problems whose boundary conditions make them all but impossible of solution.

For example, much fruitful work is to be done in the untouched field of stress relieving curves. The sophisticated designer has been taught to incorporate generous radii at abrupt changes of boundary contour—but he still puts in segments of circles because he has a compass. The author has found that elliptical blending curves are much more effective than circular radii in preventing bursting of turbosupercharger wheels. Other curves may be even more effective.

The most powerful educational advantage, however, lies in the tremendous eye-appeal of the method. The visual impact of a photoelastic image drives home the fundamentals of sculptured design for fatigue-tough structures as no other method can do. No other method so quickly emphasizes the importance of stress distribution in so colorful a manner. The entire stress pattern, the local "hot spots" in the design where failure will initiate are presented to the student either in all the colors of the rainbow or with the detail of a fine etching and the brilliance of mathematical perfection.

Photoelasticity does not measure the properties of materials: it does measure the relative values of the stress from point to point within the boundaries of a strained shape—hence the picture of "stress distribution" and the arresting emphasis on the "hot spots" where failure will initiate.

The theory can be simply stated. Certain materials exhibit double refraction when strained—the amount of double refraction is proportional to maximum shear stress. This is the basis of the exact one-to-one correspondence of the photoelastic image and the mathematical behavior of any strained elastic body.

It only remains to examine the degree and distribution of double refraction to get the complete picture of the stress distribution. Note that the image depends only on the shape of the model and the manner of loading. This is the great short cut through tedious mathematical methods where boundary conditions in complicated shapes severely limit quick analysis. Cut any shape the imagination can conceive: load it in any manner you wish: the picture is correct and easily interpreted. Prove the simple case of two point bending and reach out from there.

Double refraction results in interference phenomena when examined under polarized light and this is the basis for the optical set-up used to examine the stress pattern.

Color Patterns and Stress Distributions

When using white light, having a continuous spectral distribution for illumination, one frequency will be cancelled out by interference at each point of constant double refraction (constant maximum shear) leaving a brilliant color which is white light minus one frequency.

The colors do not appear in the usual rainbow sequence: they are brilliant and arresting.

These are the isochromatic lines—lines of constant color—lines of constant maximum shear.

The first color appears at the point where the structure will fail and will repeat itself as the load is increased until the "hot spot" is surely marked for attention. The remainder of the structure assumes the characteristic hues in a lazy manner, showing that generally the material is not working very hard; while the "hot spots" painfully assume most of the burden.

Such a demonstration never fails to open a world of feeling and speculation to the young student or engineer who may have wondered how far P/A and Mc/I can take him in the field of aircraft structures, for example, where every pound of material must do its utmost without failure.

When using monochromatic light where only one frequency is present, the image has the detail of a fine etching and the brilliance of mathematical perfection. The 5460Å line in the mercury spectrum is a popular source of monochromatic light since the line is brilliant and excellent filters are available for isolating it. Monochromatic illumination at a single frequency is cancelled out by the double refraction: so there are no gradations of color to keep track of—the image is a series of black and green lines—exquisite in detail and sharpness. If these lines of constant maximum shear are sketched or photographed, one immediately has a contour map of a "rugged terrain" whose altitude at any point equals maximum shear.

Another interference phenomena, best exhibited under white light, occurs where the principle stresses are parallel to the plane of polarization of the polariscope. Thus, with plane polarized white light, black lines will be superimposed on the brilliant colors. These black lines are the locus of all stresses parallel to the plane of polarization.

Sketch these black areas, noting the plane of polarization: shift the plane of polarization a few degrees and sketch the new locations of these black areas: repeat. Such a procedure, taken through 90 degrees produces a map of the stress trajectories: the flow of stresses in the strained shape is immediately apparent.

These are the isoclinic lines—lines of constant stress inclination.

There are two considerations that prevent photoelasticity from being king of all experimental methods in simplicity, speed. and comprehensiveness. Neither of these considerations are blank wall limitations: in fact, surmounting them only appears complicated by contrast with the utter simplicity of what has gone before.

First: While the isochromatic lines (lines of constant maximum shear, which is $(p\text{-}q)/2$,) and the isoclinics (lines of constant stress orientation) can be sketched in a few minutes, the separation of the p and q stresses from the $(p\text{-}q)/2$ information takes longer. There are several methods of effecting this separation which are treated in the standard texts on the subject.

In this connection, the author would like to make a practical point. It is not necessary to separate p and q stresses at the boundary, since the normal component q vanishes at the boundary. Hence, the value of the isochromatic line where it intersects the boundary is the value of the tangential stress at that intersection.

The boundary stresses can be read with the utmost ease. Since most of the trouble with a structure occurs at the boundary, it seems to the writer that enunciation of p and q stresses in the body of the specimen has more academic than practical interest.

Second: While the method is fast, easy, and direct in two dimensions (models can be cut from flat plastic in ten minutes from the template), the technique of three dimensional photoelasticity is more difficult and painstaking by contrast.

The method consists of "freezing" the stress pattern in a lumpy piece of plastic whose shape is under investigation: then slicing the model on appropriate planes. Slicing does not disturb the stress pattern if done carefully. After polishing to constant thickness, the slices are examined as a two dimensional specimen with the same ease as before. The author, in several investigations, has used this method and is not impressed by the alleged "difficulties" of three dimensional photoelasticity.

Educationally, from where the teacher-student sit, all the feeling for flow of stresses, the necessity for blended sculptural design, and solutions of many important plane stress problems are quickly and easily apparent from two dimensional studies. There is no dearth of interesting and fruitful cases in two dimensions. Suffice for the student to know that excursions into the three dimensions follow exactly the same principles at the price of a little more work.

The requirements of a photoelastic laboratory are simple and inexpensive.

Model Making

Sir David Brewster enunciated the principle of "forced double refraction in glass" before the Royal Society in 1816.

The succeeding struggles of those who satisfied their intrigue with the method by working in glass certainly erected some sort of monument to scientific curiosity. Mesnager studied a complete arched bridge made of glass in 1916.

Glass is many times more difficult to work than some of the available plastics and these easily worked materials are many times more sensitive for "forced double refraction." Models will occasionally break. In glass, it must have been a catastrophe: in plastic, the author's technique has a new model ready in ten minutes.

The best all around plastic is known as CR-39. CR-39 is available in flat sheets whose polished surfaces are entirely adequate. It is very inexpensive compared to others, has negligible ageing, and can be easily machined with strain free edges.

The essence of producing a strain-free edge is to cut the edge: it must not be rubbed. Edge stresses are heat stresses resulting from rubbing by dull tools or improperly ground tools. The writer has found that a 1/4″ diameter tungsten carbide cutter with 48 teeth, running at 20,000 rpm, cuts CR-39 and does not rub it. Very light cuts are taken at quite fast feeds. Tungsten carbide stays sharp and maintains its cutting edge on CR-39. Other materials dull quickly.

A sturdy template is prepared from ″.100 brass or aluminum of the desired shape and the plastic sheet is scribed from this template leaving about 1/32nd inch all around. This does not have to be too accurate. The model is sawed from the sheet using a high speed vibratory jig saw with short rapid strokes. The plastic, fastened to the template, is guided against the high speed cutter in two cuts, a roughing and finishing cut. Only ″.005 is taken off at the last cut. The template is not mutilated and is thus available for a series of models or quick replacement in case of breakage of the model. Using a nicely aligned spindle and work table, strain-free square-edged specimens can be made in ten minutes from the template.

Loading the Model

The loading frame should be equipped with shackles, pins, etc. so that tension, bending and compression may be imposed on a model. The guillotine type of loading frame is the most versatile.

The loading mechanism should be arranged to gently load and unload the model while the image is being examined. In this way, the first lines to appear can be identified and proper values assigned to succeeding lines. The manner in which the stress pattern builds up is the key to reading the stress distribution, the location of the "hot spots," the points of contraflexure, and the socalled isotropic

points which are the areas where the principle stresses are either finite and equal or equal to zero. From elastic principles, no stress can exist in a corner whose angle within the model is less than 180 degrees. Hence, such points are landmarks of known zero stress from which values can be assigned to adjacent lines. A student can learn to read the pattern as it forms in about ten minutes, once the pertinent features are pointed out to him.

The essence of fast interpretation is to have controls of the load right at the viewing station, so the load can be changed while the model image is being studied.

It is helpful to have the loading mechanism adapted for slow loading by means of sand, lead shot, or water. Movies of the build up of the stress pattern taken under such loading conditions can be striking when shown to a large group.

The Polariscope

The polariscope should be equipped with both white light and a mercury vapor lamp provided with suitable filters for isolating the 5460Å line. This is a good line because it is brilliant, the available filters are good and it is good photographically. The two light sources should be mounted so that either may be quickly selected.

It is essential that the model be illuminated by a beam of parallel light. If the light through the model is not parallel, false readings will result; because the interference phenomena on which the method depends, has the thickness of the model as a parameter. Thus, non-parallel light travels a longer path through the model than a parallel beam and results in false data. For the same reason, the square-edged specimen discussed under model making is essential if boundary stresses are to be accurately read.

Aspheric lenses having parabolic surfaces are excellent for producing maximum intensity beams of parallel light, since such a figure can be made to work at small F numbers.

Polaroid, preferably in glass, is the best means for producing a large aperture beam of polarized light.

Quarter wave plates are essential to a working polariscope. They take out the isoclinics (lines of constant stress orientation) so that the constant shear lines are uncontaminated while the stress field is being evaluated. They should be mounted so that they may be used either in the crossed or parallel position. The crossed position results in a dark field background, while the parallel position reverses all lines and gives a bright field background. This is useful in boundary stress evaluation since it seems easier with a bright field to locate the exact point of intersection of a given line with the boundary of the model.

A collimating lens then brings the parallel beam into an image forming lens.

A most convenient sketching arrangement is provided by incorporating a prism at this lens station so that the image of the specimen is projected downward on a sketch pad rather than horizontally onto the conventional screen. Manually sketching the lines of the phenomena augments the visual impact. Educationally, this is of extreme importance in fixing the content in the student's mind.

The polarizer and analyzer should be synchronized together in the crossed position and rotatably mounted so the plane of polarization can be varied at the sketching station without the inevitable distraction that accompanies fussy adjustments with each unit, reading the corresponding angles and making sure the two are always crossed as the plane is changed. Thus, the attention can be focussed on the main event.

To summarize the educational advantages of the photoelastic method as an adjunct to courses in strength of materials and structures:

(1) The method is exact and quantitative.

(2) The method has no limitations as to complexity of shapes that may be evaluated.

(3) Simple, versatile techniques and apparatus are available.

(4) Use of the method develops feelings for the flow of stress in a structure, emphasizes the need for sculptured design, points up the origin of fatigue failures, and, in particular, makes the student wary of the "sharp corner" trap into which so many designers have fallen.

(5) The method has tremendous eye-appeal which can be augmented by the manual exercise of sketching.

In the News

The following letter was sent by Engineering Manpower Commission to Senator Richard B. Russell, Chairman of the Senate Armed Services Committee, and Representative Carl Vinson, Chairman of the House Armed Services Committee, on April 25. The information therein was also furnished to General George C. Marshall, Secretary of Defense.

"The Engineering Manpower Commission, formed by six leading professional engineering societies having a combined membership of 140 thousand engineers, is concerned over the shortage of engineers available to the Armed Forces and to civilian activities essential to the country in the present emergency. In view of such shortage, the Commission is urging the necessity of conservation of the important resource of men trained and experienced in engineering to the end that a balance of supply be maintained between these components needing such specialized personnel. We are further urging that such personnel be employed so far as possible in ways utilizing to a maximum degree the training and experience they possess. The Commission recognizes that there is no group in our country that may substitute for the engineers. This makes more compelling the need for wise and efficient deployment of the service they are willing and eager to render.

"A very large number of engineers now holding some form of reserve status are engaged in civilian occupations vital to our security and welfare. Thus the utilization of the talents of these men effects both civilian and military necessities. It is the belief of the Commission that proper use of these necessary specialized personnel cannot be insured if decisions on individuals be made by persons who reflect one category of need primarily, but that both civilian and military needs must be met from the limited supply through joint decision of civilian and military agencies.

"The Commission, therefore, by unanimous action at its meeting on April 24, 1951 endorsed the provision of the Bill S.1 as amended and printed on April 17, 1951, beginning with line 23, page 55 to form 'one or more civilian reserve deferment appeal boards' to deal with the calling of reservists. It is suggested that military representation might properly be included on such board or boards, and that, to give effect to such participation, the word 'who' in line 3, page 56, be replaced by 'a majority of whom.' A similar board should be created and charged with the coordination of regional boards. The Commission otherwise endorses the provisions for the boards of the amended bill from line 23, page 55, including line 2 page 57."

Respectfully submitted,

ENGINEERING MANPOWER COMMISSION
CAREY H. BROWN, *Chairman*

Drafting Problems Encountered in Structural Steel Fabrication

By R. M. SHERMAN

Executive Engineer, Central Texas Iron Works, Waco, Texas

The title of this paper "Drafting Problems Encountered in Structural Steel Fabrication" lends itself to more than one interpretation as to the context of this writing. I shall treat this subject from the standpoint of the drafting department of a structural steel fabricator considered as a definite unit of the business and shall discuss the many problems involved in the operation of this unit. In preparing this paper, I want to acknowledge the helpful advice and council of Mr. M. R. Van Valkenburgh, whose many years of experience in this field have made him a recognized authority.

Since structural steel in its final fabricated form is almost invariably incorporated in structures wherein public safety or public health is involved, it becomes necessary to provide that its design, fabrication and erection be done by or supervised by Professional Engineers. All forty-eight States have statutes which generally place this responsibility in the hands of Registered Professional Engineers. In this three-step process of design, fabrication and erection, the structural steel fabricator holds a key position. It is his responsibility to faithfully carry out the requirements of the design drawings through his own processes, which substantially consist of two steps; the making of shop details and actual shop fabrication. For fear of over-simplification of this process, let it be stated that the entire structure of a structural steel fabricators organization is complex and intricate. requiring major financing, much experience and the application of professional knowledge and special skills.

The purpose of the preceeding observations is to place the making of shop details—the drafting department in this organization—in its proper and vitally important place in this process of design, fabrication and erection of structural steel. In its own organization, the drafting department, to quote from the recent handbook on Structural Shop Drafting published by the American Institute of Steel Construction, is "the hub around which all operations turn."

The one purpose of the drafting department is to interpret intelligently plans and designs prepared by practicing Professional Engineers and to convey these interpretations into structural shop details which, when used to process structural steel shapes, will result in a structure which will be a faithful reproduction in steel of the designing Engineers plans.

Organization of the Drafting Department

The conventional organization usually consists of a Chief Engineer, a Chief Draftsman, checkers and detailers, wherein the Chief Engineer is the general executive director of the drafting department as well as the Engineering Executive for the entire organization, with the Chief Draftsman in direct charge of the management of the drafting department and scheduling the work so that orders are processed in the proper sequence and in such a manner that the talents of his men are used to the best advantage.

* Presented at the Mid-Winter Meeting of the Engineering Drawing Division, ASEE, Texas A. & M. College, January 19, 1951.

It is under the direction of the Chief Draftsman that all shop details are made and it naturally follows that he is responsible for the accuracy of the drawings, maintaining of standard procedures, and the solution of technical and mathematical problems.

It would appear that a drafting department, to operate with the most efficiency, should be manned by Engineering graduates with years of experience. However, from an overall standpoint, the tasks to be performed vary from the most menial and relatively simple to the most intricate and involved, and therefore, under professional supervision, it is possible from a standpoint of economy to use men of lesser education and experience in the lower bracket and men of more experience and education in the upper bracket. One of the problems of a drafting department is proper balance of experience to inexperience and a balance in the various levels of education.

It would be possible to operate a sizeable structural drafting department composed of draftsmen whose education extended very little past high school, provided the experience factor was in the proper proportion, but very few fabricators would want such an organization. Structural steel is purely an engineered product and one of the most important points of control, the preparing of shop details, cannot be entrusted entirely to the layman. Therefore it becomes necessary to have in the drafting department organization a sufficient number of key personnel who are Professional Engineers and who have sufficient experience to give them an easy and ready knowledge concerning the engineering plans with which the department is working. These men are usually assistants to the Chief Draftsman or are checkers or squad leaders.

The importance of engineering knowledge and experience in the drafting department cannot be overestimated, for it is easily possible for serious weaknesses in the finished structure to develop through ignorance of engineering principles while the shop drawings are being made. It is true that it is customary for the designing Engineer to check the shop drawings upon completion to see that all connections are safe and that all framing is handled properly before the drawings are placed in the shop for fabrication. Such checking, however, is a tedious chore, and many designing Engineers only give the drawings a rather rough check and rely upon the fabricator to have a drafting department of high enough professional level to eliminate connection and framing errors and at the same time possibly catch some errors the Engineer himself might have made. Such practices are probably frowned upon by the elite in the Consulting Engineering field who operate large organizations, but still a large number of smaller operators to some extent rely upon the professional knowledge and integrity of the steel fabricator.

Since the steel fabricating business as an industry is solidly founded and relatively free of "in and outers," most fabricators have built their drafting departments along such lines that they are capable of assuming the responsibilities just described. The exceptions are small shops which have sprung up with the advent and universal use of electric arc welding wherein the equipment needed, if the projects are chosen for the purpose, is hardly more than acetylene torches and electric welding machines. This is not at all intended to be a criticism of these processes but shops capable of fabricating only by these methods have a relatively small financial investment and have generally been operated without professional services. If the element of engineering is eliminated, such organizations are wholly incapable of being entrusted with the fabrication of structural steel.

Drafting Practice as Preparation for Consulting Engineering

In order to maintain such an organization, many steel fabricators follow the practice of employing young College graduates just out of school to begin

work in their drafting departments. Experience and the normal turnover in personnel which occurs in any organization generally allow these men to advance to positions of responsibility in a few years. At the same time, it is generally necessary to employ young men of lesser educational background who generally come under the direction and supervision of the Professional Engineers in the organization. Engineering graduates who eventually intend to go into the Consulting field can find no better background for their future professional life than a number of years in the drafting department of a structural steel fabricator. One consulting Engineer known to me, who maintains a sizable organization, will not employ a young engineering graduate unless he has served several years with a structural steel fabricator, and this point is made to further emphasize the existence of engineering practice, responsibilities and atmosphere that exist in the making of shop drawings.

The structural steel fabricator does not object too strenously to providing a training field for engineering graduates who intend to go into Consulting Engineering work and other allied fields provided he can have these men long enough to recover some of the investment he puts into them during the first year or year-and-one-half of their employment. It is difficult to set a time limit which differentiates between inexperience and experience in the field of structural drafting and naturally opinions vary. However, it is generally felt by many steel fabricators that a college graduate after one years employment is then ready to absorb good solid experience at a rapid rate and could be considered an experienced detailer at the end of two or three years when under the supervision of Engineers who have been in the business a considerable length of time. For the non-college graduate, the time schedule would have to be multiplied by two or three plus outside study, and such personnel would generally not be capable of rising above a certain level. Heads of Engineering Departments in colleges and universities sometimes advise their students in structural design to get their first experience with a steel fabricating company. I know of one individual in this capacity who has followed this practice for many years.

Training Problems

In training engineering graduates, the fabricator is confronted with a number of problems. One of them which is almost immediate is to eliminate from the mind of the new employee any idea that he is expected to know anything about the steel fabricating business in general or about structural drafting in particular. I have found that it is a good idea to advise him that his engineering degree is evidence enough that he has studied and has been found proficient in the basic courses of mathematics, physics, mechanics and the basic courses of his engineering major. It is also well to advise him that these courses comprise his formal education and that the fabricator is not equipped to carry these on any further on a formal basis, but that his education has given him the capacity to properly absorb and benefit by the experiences which will come to him.

A surprisingly large number of graduates will become discouraged and change to some other field if they are not given assurance such as described, that their inability to produce immediately after graduation is natural and expected. As an overall average, a young engineering graduate can be expected to turn out structural shop drawings profitably at the end of one year. Even so, he would be limited in the type of detailing he could do. If the work of the fabricator with whom he is connected is of a general nature and covers most types of structures, he can be expected to become rather expert at the end of four or five years. To the uninitated, it does not seem reasonable that so much time should be required, but as pointed out earlier, the steel business is of a complex nature and in order to reach mature experience,

it is necessary to absorb many intangibles in addition to mastering the concrete operations. Although I am sure that the engineering schools endeavor to teach their engineering students something about the steel business as a whole, I still run into graduates now and then who do not have a very clear conception as to the difference between a steel fabricator and a steel mill. Of course, misconceptions such as this might be corrected by a word or two, but there are literally hundreds of such situations and minutiae where only time and experience can give to a person a quick and easy knowledge.

Field trips in the senior year in college are a great help in fixing in the students mind the results of engineering practice and in its contribution to society, but it is equally important that these trips be planned very carefully. The time alloted to these trips, from my observation, is usually short and as a result, plant or project visitation is hurried and somewhat ineffective. Plant or project officials are usually willing and cooperative in giving their time to these field inspection trips, but I know of several individuals including myself, who have felt that the hurried atmosphere caused by a crowded and tight time schedule, did not permit a thorough briefing on the project or process and as a result, the knowledge gained was too cursory to be of much value. It is of great interest to structural engineering students to see engineering structures in the process of building, but since steel is the basic material with which a structural engineer works, I feel that it is most important that a structural engineering major have in his field inspection schedule an unhurried trip through a steel mill to see where and how steel is made into usable shapes, and then go through a steel fabricating shop including the drafting department, spending enough time to actually see how these shapes are made into usable structures. I feel that such inspection trips as just described are actually more important to the structural engineering student who does not intend to work for a structural steel fabricator, for if he does not avail himself of this opportunity while in engineering school, the chances are that he will not do so later.

In starting an engineering graduate in structural drafting, one of the problems is to each him to read engineering and architectural plans. Unfortunately this cannot be done in three easy lessons, and as a matter of fact, this might be the crux of the whole matter of structural drafting, for if a person can interpret accurately and in detail engineering and architectural plans, it is much less difficult for him to convert these interpretations into shop drawings. Some of the most costly errors made on shop drawings and not discovered until the steel erector has endeavored to put the steel together on the job, have been caused by a misinterpretation of the engineering plans. Sometimes this is carelessness on the part of several people, but many times it is due to ignorance of plans. Mark Twain is said to have remarked that "a man endowed with ignorance and self-confidence is sure of success." This of course was said facetiously and may even have some degree of truth for some lines of endeavor, but in structural drafting such a philosophy is certainly false. In fact, ignorance or inexperience will come out quickly in the drafting room, and the man who tries to bluff his way will be caught before sunset.

Starting at the beginning of an engineering education, the foundation of reading plans and making understandable drawings is laid. I speak of such courses as engineering drawing, descriptive geometry and the basic courses in mathematics. Often these courses are touched upon only lightly during the remainder of an engineering curriculum and as a result are largely forgotten by the student by the time he graduates, only to suddenly find upon obtaining employment, that the ghost he rid himself of many years before has miraculously come to life again. I know that educators are hard put to squeeze into four years the

bare necessities of an engineering education, but some means should be found to keep fresh these basic courses.

Employing Graduates

A steel fabricator has a problem when it comes to interviewing with reference to employment a young man who is about to graduate. I have interviewed many of these students, who at the time of the interview were finishing their senior year and were involved in intricate engineering problems which later would only be entrusted to those of long experience. I am then confronted with the unpleasant task of informing them that to begin in the steel busines it is necessary to go back four years and take up drafting again. I am serious when I say that this comes as a shock to four out of five students, and more often than not causes the student to search in other fields for employment. Some people consider drafting one of the menial tasks of engineering and if followed without professional knowledge, the person may be no more than a stenographer of the drafting board, merely putting down what others dictate. If this be true, it must be stated, however, that such dictation is not done orally, but is transmitted through drawings, and I submit to you that an engineer who cannot express himself through intelligent and legible drawings is in no better position than a doctor who could not put down in writing one of his prescriptions for others to fill, but would have to go to the drugstore and mix it himself.

In training for structural drafting, the best teacher is experience although books of standards and outside reading are aids. One of the most prevalent shortcomings in individuals in this work centers around those things taught in descriptive geometry and similar courses. The Encyclopaedia Britannica is dissertating on the subject of descriptive geometry states that "it is the means by which the designer conveys his ideas to the builder or mechanic, and has been called the universal language of the engineer." Further than that, it tends to develop in an individual a sense of perception which makes it possible for him to from and visualize in his mind three dimensional objects taken from what he sees drawn on two dimensional paper. Some people have this ability as a natural aptitude and others have to develop it through study and practice, but whether acquired or natural, the structural draftsman must somehow achieve an easy and comfortable use of this faculty.

The more advanced structural shop drawings are considered such because they incorporate some of the more intricate phases of descriptive geometry. Under this heading is included hip and valley work, bins and hoppers, various types of storage tanks and numerous other situations where steel members are framing at angles with each other and in several different planes. The usual procedure in training draftsmen is a block on top of block process beginning with the simple and elementary and progressing towards the intricate and complex. Some fabricators, however, who do a specialized line of work, are able to get out rather involved work utilizing draftsmen of limited overall experience by having experienced engineers to break the work down into component parts which are then detailed along formulated lines. Detailers thus trained are often of very little value except to those specific types of work.

The larger steel fabricators, especially those of national scope, have very definite standards which form and control the method of preparing shop details. These standards will vary from one company to another, and although none of the basic principles of engineering drawing will be violated, certain conventional methods will be set down which cannot be found in any textbook. Smaller fabricators have generally taken one of three routes; followed the standards set out by one of the larger fabricators; developed at quite some expense a book of standards of their own; used a hodgepodge of methods with every newly employed

draftsman who has experience elsewhere bringing ideas of his own. Smaller fabricators in the last category are quite numerous and the hardships worked on their shops by not having definite standards is considerable.

The business of operating independent detailing offices for the purpose of preparing shop drawings for a number of different fabricators is on the increase. Fabricators who use these services generally maintain a basic drafting department, and then "farm out" to these independent agencies such shop drawings which are above the capacity of their basic drafting unit. Such services are a convenience to the fabricator as it keeps him from having to expand and contract his drafting department according to the volume of business he is able to secure. Such "farming out," however, brings up the problem of standards and method of detailing. The independent detailer may be working for a dozen different fabricators and he is faced with the dilemma of using his own standards or conforming to a particular fabricator's standards either through study or conference.

All of this brings me to the point of making the statement that the time is full ripe for the establishment on a national scale of a standard practice of detailing structural steel and the conventions pertaining thereto. The American Institute of Steel Construction has recently published a book entitled "Structural Shop Drafting, Volume I" which is a step towards standardization on a national scale. This book is called a "textbook" and it is intended to assist in training men in the field of structural drafting, but it does not set down detailing practices except in a general way. It is my understanding that a Volume II is to be published later which will establish standards and procedures. The success of such a move will depend largely upon the degree of acceptance by the industry, and especially by those who have for years followed well established standards of their own. Volume I is authoritatively written and contains enough material on structural design to warrant it being used as a supplementary textbook in senior structural design courses.

In conclusion it can be said that the steel fabricating business occupies one of the pivotal points about which the construction industry revolves and it is good that the fabricators have organizations directed largely by Registered Professional Engineers who are capable of taking fine engineering designs prepared by Consulting Engineers and converting them faithfully into steel structures. Such work is very satisfying and challenges the best engineering talents. The steel fabricating business offers the young graduate an authoritative continuation of his engineering education, and though it does not promise him a disproportionate compensation, it does hold for those with ability and a desire to work many oportunities for advancement into the executive field. The steel business needs and deserves the sharpest men the engineering schools can produce and although the industry can compete for these men on an equal basis with other fields, students have too often been advised that other divisions of engineering were more lucrative. It is hoped that through the medium of such groups as this one, that authoritative information concerning various branches of industry can be disseminated to the students so that they might make their decisions without prejudice or false impressions.

A Simple Electronic Differential Analyzer as a Demonstration and Laboratory Aid to Instruction in Engineering

BY M. H. NICHOLS [1] AND D. W. HAGELBARGER [2]

University of Michigan College of Engineering, Department of Aeronautical Engineering

Introduction

The demonstration of such things as dynamics of mechanical systems, statics and dynamics of beams, etc., by mechanical means is often expensive and inconvenient. The demonstration of such idealizations as purely dry or purely viscous friction is difficult, if at all possible, by mechanical apparatus. Many of these demonstrations are more conveniently handled by use of an electronic differential analyzer and, in general, do not lose their instructional value. Over the past several years, the authors have used the electronic differential analyzer for laboratory instruction in an undergraduate instruments course and in a servomechanism course and have received enthusiastic response from the students. In addition to providing an insight into the behavior of the systems studied, setting up the differential analyzer, arranging the initial conditions, etc., help the students get a "feel" for differential equations as expressions of the behavior of physical systems.

The purpose of this paper is to describe the use of a simple electronic differential analyzer[3] for laboratory instruction and lecture demonstration. Several examples will be worked through completely and additional possibilities will be suggested. Upon sufficient experience, the extension of the computer to the demonstration of many other engineering problems becomes apparent. Although the apparatus, with the possible exception of the recording instrument, can be duplicated in most college shops, space does not permit a complete description of each component and a detailed description of the use of the analyzer. However, such information may be obtained in detail by writing to the first author and to emphasize this, a double asterisk (**) will in the following denote some of the topics on which detailed information is available. Since the fundamental theory of this type of computer is well discussed by Ragazzini, Randall, and Russell[(1)] and by Frost,[(2)] it will not be repeated in this paper.[4] The basic component of the analyzer is a high gain d.c. amplifier. The amplifiers used for the results presented in this

[1] Now at California Institute of Technology, Pasadena, California.

[2] Now at Bell Telephone Laboratories, Murray Hill, New Jersey.

[3] Another type of electronic computer, usually called an analogue computer, makes use of inductances, capacitances, and resistances, connected circuitwise to simulate the system under study. See, for example, McCann, Wilts, and Locanthi, IRE, *37*, 954 (1949); McCann and MacNeal, ASME Jour. Appl. Mech., *17*, 13 (1950) and references thereto. In the case of continuous media, the method of difference equations is used.

[4] It should be mentioned that Ragazzini et al.[(1)] use only the differentiator type of amplifier connection, whereas it was later found that the integrator type of connection is more practical and can be used to accomplish the same results. Frost[(2)] discusses the connections for integration.

paper are described by Ragazzini et al.[1] More recently Frost[2] has described a similar amplifier which may be more advantageous for demonstration purposes because it provides a higher current output which permits the use of a wider variety of recording and observing instruments. The recordings presented in this paper were made by a Bruch Development Company type *BL202* magnetic pen recorder but a wide variety of recording and observing instruments, including cathode ray oscilloscopes can be used. A complete description of the auxiliary power supplies, etc., may be obtained.**

Type of Systems Which Can Be Handled by a Simple Electronic Differential Analyzer

A differential analyzer can be arranged to obey the differential equations which describe the system to be investigated.[1, 2] With only the basic d.c. amplifier and simple condensers and resistors it is easy to handle ordinary linear differential equations of the type

$$\begin{aligned}(Ap^{m-n} + Bp^{m-n-1} + Cp^{m-n-2} + \cdots)y \\ = (\alpha + \beta p^{-1} + \gamma p^{-2} + \cdots \eta p^{-n})x, \quad (1)\end{aligned}$$

where p denotes differentiation by the independent variable (p^{-1} denotes integration), the coefficients A, B, $C, \cdots$, α, β, $\gamma, \cdots$, etc. are constants, y is the dependent variable and x is an arbitrary function of the independent variable. In many cases, x may be considered as a forcing function. It is also easy to handle systems of equations of the type (1)—i.e., coupled systems with only one independent variable but with several dependent variables. In the case of the differential analyzer described here, the independent variable becomes time and the variables x and y are voltages. Examples of systems which are described by equation (1) are simple one dimensional linear vibration,[4] seismic instruments,[4] linear servo systems,[5] uniform thin beams,[4, 6] etc. By using the d.c. amplifier in its non-linear range, it is possible to handle such things as dry friction,[4] bang-bang controlled servos, etc. By means of more complicated devices such as synchronously driven switches or potentiometers, servo multipliers, etc., more complicated differential equations can be handled[1, 2, 3] but these will not be discussed in this paper.

Use of the High Gain D.C. Amplifier to Perform Elementary Operations

Figures 1A and 1B on page 118 of Frost's paper[2] show how the d.c. amplifier can be used to sum and to integrate to a high degree of accuracy if the gain of the amplifier is sufficiently high. The relations given in connection with this figure can be easily proved by applying Kirchhoff's laws to the input terminal of the amplifier under the assumption that the gain of the amplifier and input resistance to the amplifier are both very large.[1, 2] In order to use the amplifiers as they are connected in Fig. 1 of Frost's paper, it is necessary that the output voltage be opposite in polarity from the input, otherwise the feed back connection would represent an unstable system. It is also possible to differentiate[1] but this is generally not practical because of the resultant amplification of stray 60-cycle pick up and the instability resulting from phase-shift characteristics of the amplifiers at high frequencies.

A general arrangement of amplifiers which obeys equation (1) with positive coefficients is shown in Fig. 1, in which the condensers are all taken as one microfarad for convenience, and all resistors as are in units of megohms.[5] In particular cases, there are alternative connections which sometimes make possible the elimination of one or more amplifiers, but Fig. 1 can be used as a guide for setting up the problem. The following

[5] In the case of negative coefficients, the appropriate connections should be changed from bus (1) to bus (2) or vice versa. That the arrangement of amplifiers in Fig. 2 satisfies equation (1) can be shown by applying Kirchhoff's current law to the junction "J."

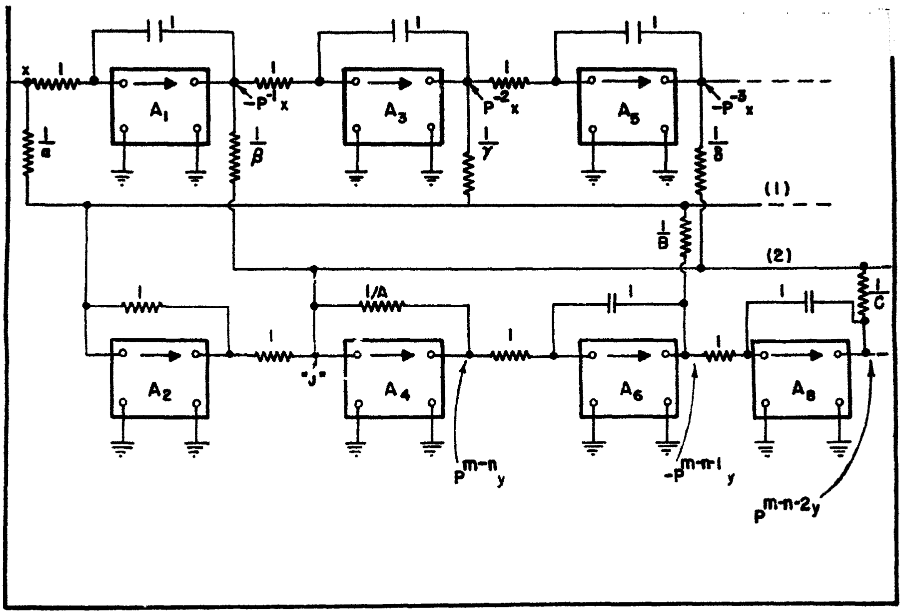


FIG. 1. General arrangement of amplifiers which obeys equation (1) with positive coefficients. All capacitors and resistors are in units of microfarads and megohms, respectively.

examples will illustrate the arrangement for some common engineering problems and will show how initial conditions are handled.

Examples

Example 1. One Degree of Freedom Vibration.

Consider the spring, mass, and viscous damper system represented by Fig. 23 on page 34 of reference (4). Let a force $x(t)$ act on the mass. Then equation (1) for this case becomes

$$(Ap^2 + Bp + C)y = x(t), \tag{2}$$

where A represents the mass, B the viscous damping coefficient and C the spring constant, $\alpha = 1$, $\beta = \gamma = \delta = 0$. Referring to Fig. 1, it is seen that in this case amplifiers A_1, A_3, A_5, etc. are not used—i.e., only amplifiers A_2, A_4, A_6, and A_8 are used. It is also possible, and sometimes convenient for varying the parameters—i.e., mass, damping, and spring constant—to make the resistors $1/A$, $1/B$, etc. some nominal value, say one megohm, and to put a voltage divider of around 50,000 ohms total resistance across the outputs of amplifiers A_4, A_6, and A_8 so that the proper fraction of the output of these amplifiers can be fed back to the junction J.** The forcing function $x(t)$ may take the form of a step function voltage or a sinusoidal voltage both of which can be easily produced, the first by a battery and a switch and the second by simple electromechanical or electrical means.** Various sinusoidal frequencies can be combined for a Fourier series synthesis of $x(t)$ etc.[6]

[6] It should be mentioned that by using the proper feedback connection it is possible to handle equation (2) with only three amplifiers instead of the four indicated by Fig. 1.** Also, if $B > 0$ then it is possible to handle equation (2) with only one amplifier by means of added associated resistors and condensers (2).** This latter is essentially a combination of differential analyzer and analogue computer.

Initial conditions can be easily inserted by means of batteries and switches which are opened at time $t = t_0$.** In the case under consideration the initial condition y_0 can be inserted by connecting a battery of voltage y_0, by means of a switch (or relay), across the feed back condenser of A_8.** If y_0 is positive, the positive terminal of the battery should be connected to the output terminal of A_8. The initial condition on $(dy/dt)_{t_0}$ is applied in the same manner. Figure 2 is a photograph of a four amplifier unit connected to obey equation (2). The chassis on the left is an electromechanical sine wave generator constructed from a synchronous motor and a war surplus selsyn generator.** The initial condition relays are fastened to the top of the two feed back condensers which appear on the lower right side of the photograph. By proper adjustment of the input and feedback elements it is possible to change the time scale for more convenient observation of the output and to change the voltage level in the amplifiers for operation in the optimum voltage range.**

By using the computer connection from Fig. 1 it is easy to run off the steady state response for various values of the damping ratio[4] as a function of various sinusoidal forcing frequencies giving both amplitude and phase response.** Also various transient effects can be easily handled.**

Example 2. Spring and Mass with Dry Friction.

This is a non-linear problem[4] and cannot be handled by Fig. 1 but can easily be handled by making use of the saturation characteristic of the amplifier.** This can be done by using the same amplifier connection as for equation (2) except that the feed back resistor $1/B$ should be about 50,000 ohms and the feed back resistor from output to input of A_2 should be about 30 megohms. This causes amplifier A_2 to saturate and thus to put out a square voltage wave which changes sign each time the velocity, $\dot{y}$, changes sign thereby representing a dry friction force. A voltage divider (of about 50,000 ohms total resistance) can be put across the output of amplifier A_2 in order that the desired amount of dry friction force can be fed into A_4. If a forcing function is desired, minus $x(t)$ can be fed through the resistance $1/\alpha$ into A_4. Actually this connection of amplifier A_2 results in a square wave which is not symmetric about the zero voltage level. This defect can be rectified by the proper connection of an additional amplifier.** In most cases this asymmetry causes no trouble because its effect may be considered as a constant displacement of the system.

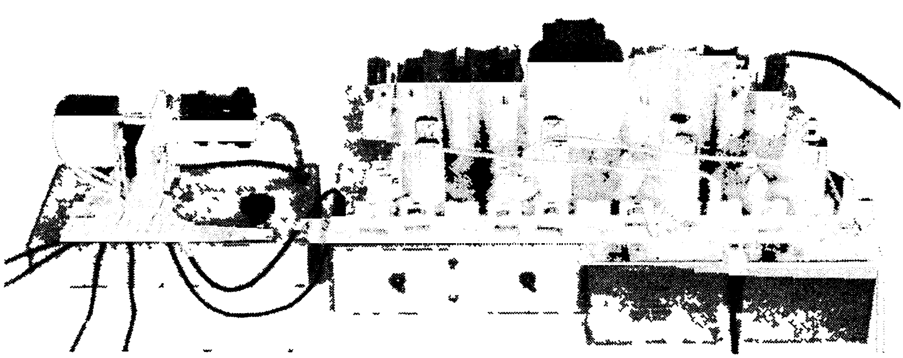


FIG. 2. Photograph of a four amplifier unit set up to obey equation (2) with an electromechanically generated sinusoidal forcing function.

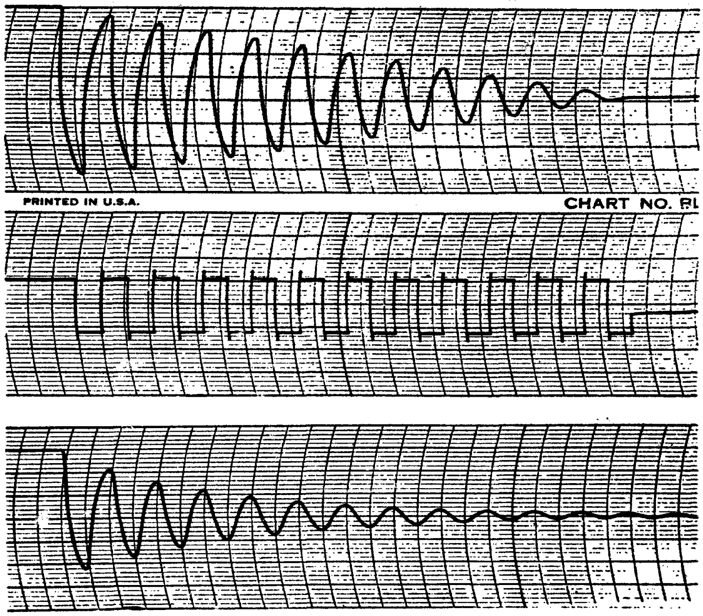


FIG. 3. Step function response of a mass and spring system with dry friction, top, as compared to the same system with viscous friction, bottom. The middle record is the dry friction force applied through the saturable amplifier; the overshoot is due to the recorder characteristic.

Figure 3 is a reproduction of a recording of a step function response of a spring and mass system with dry friction as compared to the same system with viscous friction. Combinations of dry and viscous friction in both transient and steady state can be handled by combining the methods of example 1 and example 2.

Example 3. Servomechanism.

From reference (5) page 177, the fundamental differential equation for a linear servomechanism with viscous output damping, error rate damping, and integral control may be written:

$$\begin{aligned}(Ap + B + Cp^{-1} + Dp^{-2})y \\ = (\alpha + \beta p^{-1} + \gamma p^{-2})x, \quad (3)\end{aligned}$$

where y is the output angle, x the input angle, A the output moment of inertia, $B = L + F$ (where L is the torque per unit error rate and F is the friction torque per unit output rate), C the torque per unit error angle, D the torque per unit time integral of error, $\alpha = L$, $\beta = C, \gamma = D$. This is directly handled by Fig. 1.

As an example, the response of a servomechanism to a ramp input function —i.e., the input function, $x(t)$, is a linear function of time starting at zero at time zero—will be investigated. Many ways of generating such a ramp function will be obvious, but a convenient one consisting of a single amplifier connected to integrate a constant voltage—i.e., to integrate a velocity step function—was used for this example.** The ramp function output was connected into the circuit derived from Fig. 1, which obeys equation (3), at the $x(t)$ terminals. The quantity $-y$ is taken off the output of A_6 and x is taken from the $x(t)$ terminal. If it is desired to obtain the output error $y - x$, the output of A_6 is added by a summing amplifier[2] to the ramp function voltage at $x(t)$.** The output of the summing amplifier is $y - x$.

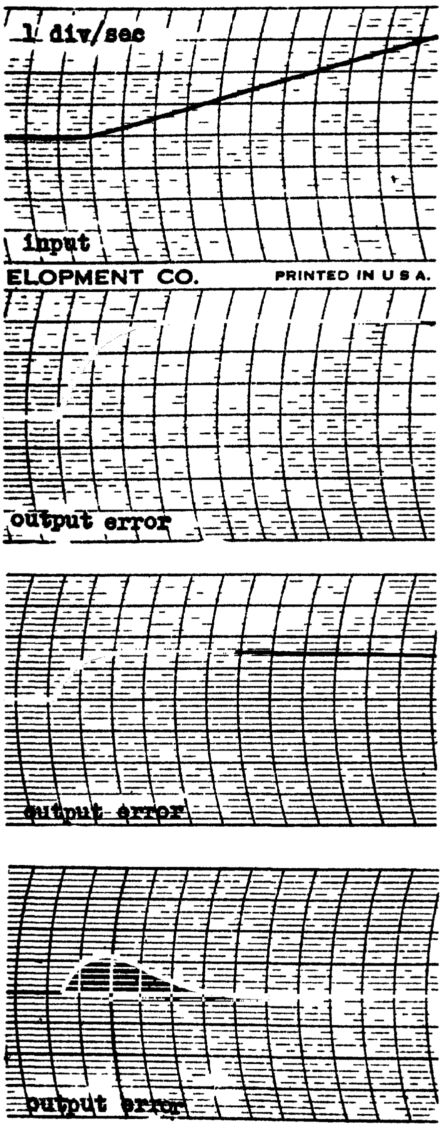


FIG. 4. Error between the output and the input of a servomechanism for a ramp function input. The top trace is the ramp function input; the next to top is the output error with viscous output damping; the next to bottom is output error with viscous output damping and error rate feed back; and the bottom is output error with viscous output damping, error rate feed back, and error integral feed back. All cases are critically damped.

Thus eight amplifiers are required. Alternative connections can be worked out.**

Figure 4 is made up of recordings for three different combinations of parameters. In this figure the ramp function $x(t)$ is recorded and the output error $y - x$ is recorded for each case. The latter is recorded with ten times the sensitivity of the former. The three cases are: Case I, $A = 1/4$, $C = 1$, $\dot{x} = 0.1$, $F = 1$, $L = 0$, $D = 0$; Case II, $A = 1/4$, $C = 1$, $x = 0.1$, $F = 1/2$, $L = 1/2$, $D = 0$; Case III, $A = 1/4$, $C = 1$, $x = 0.1$, $F = 1/2$, $L = 1/2$, $D = 1/2$. Since in each case $F + L = 1$ and $AC = 1/4$, the damping is always critical. It is interesting to note that the addition of rate feed back halves the steady state error and that the further addition of integral control reduces the steady state error to zero.

It should be pointed out that the differential equation for a seismic instrument[4] can be written in a form identical to equation (3) in which only error and rate control are applied—i.e., $D = \gamma = 0$. In this case $y(t)$ is the coordinate of the seismically supported mass and $x(t)$ is the coordinate of the support of the seismic instrument. The reading of the instrument is $y - x$. One dimensional vibration isolation problems (see reference (4) page 85) can be handled in a similar way. Such things as dry friction and bang-bang control in servomechanisms can be handled by the saturation of the amplifiers as discussed in example 2.

Example 4. Coupled Systems—The Dynamic Vibration Absorber.

In order to handle linear coupled systems with one independent variable, the computer may be set up for each dependent variable in accordance with Fig. 1. Then the necessary cross connections are made. As an example of coupled systems, the problem of the damped vibration absorber will be treated. From reference (4) page 115, the differential equations of the system

with a sinusoidal forcing function can be written

$$(A_1p^2 + B_{12}p + C_1 + C_{12})y_1 - (B_{12}p + C_{12})y_2 = P_0 \sin\omega t, \quad (4)$$

$$-(B_{12}p + C_{12})y_1 + (A_2p^2 + B_{12}p + C_{12})y_2 = 0, \quad (5)$$

where subscript 1 refers to the main mass, subscript 2 to the small mass, and B_{12} and C_{12} represent coupling terms. From Fig 1 a computer set up is made for y_1 (without the coupling terms) consisting of amplifiers A_2,[(1)] A_4,[(1)] A_6,[(1)] and A_8[(1)] A similar set up consisting of A_2,[(2)] A_4,[(2)] A_6,[(2)] and A_8[(2)] is made for y_2 A forcing function $P_0 \sin\omega t$ is inserted at the x_1 terminals. A resistance of value $1/C_{12}$ is connected between the output of A_8[(1)] and input of A_2[(2)] and another resistance $1/C_{12}$ between the output of A_8[(2)] and the input of A_2.[(1)] A resistance of value $1/B_{12}$ is connected between the output of A_6[(1)] and the input of A_4[(2)] and another resistance $1/B_{12}$ between the output of A_6[(2)] and the input of A_4.[(1)] This completes the set up.

By way of illustration, the damped dynamic vibration absorber discussed in the example in reference (4) page 128, will be simulated with $C_{12} = 8.4$ lb./in and $B_{12} = 0.054$ lb. sec /in. It turns out that with these values it is desirable to change the independent variable to a new time scale τ such that $\tau = 25t$ and to divide the equation through by 100 ** This gives in terms of megohms using slugs, feet, and seconds: $1/A_1 = 0\,515$, $1/(C_1 + C_{12}) = 0\,0757$, $1/A_2 = 5.15$, $1/B_{12} = 6.17$, $1/C_{12} = 0\,992$ Figure 5 shows the steady state response of this system to a forcing function of 53 radians per second with equal sensitivity in each

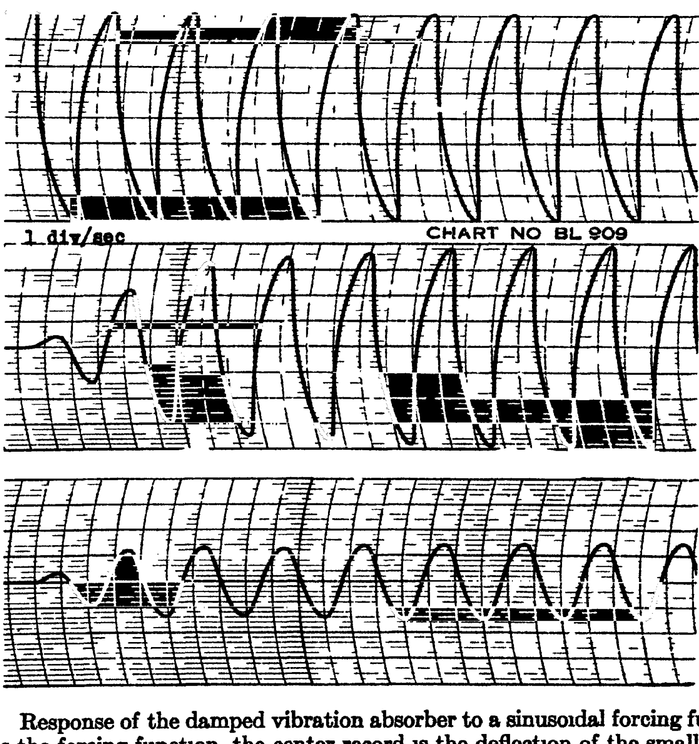


FIG 5. Response of the damped vibration absorber to a sinusoidal forcing function The top record is the forcing function, the center record is the deflection of the small mass and the bottom record is the deflection of the large mass. All the records were taken with the same sensitivity

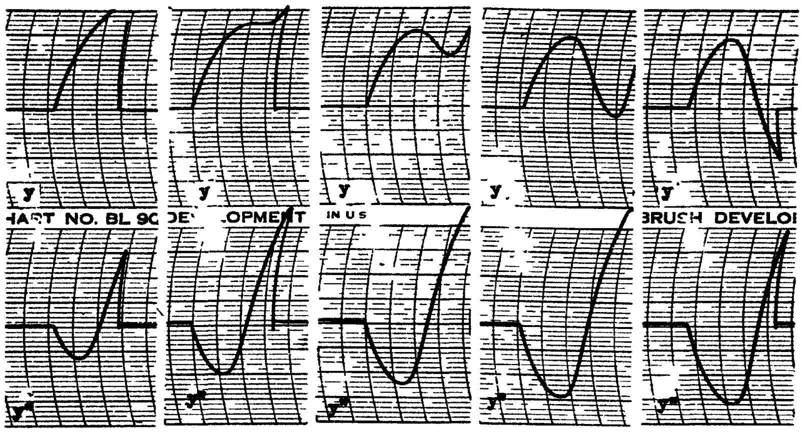


FIG. 6 Five trial solutions for the deflection of a uniform beam with uniform load hinged at the ends obtained by successive increases in V_a. The upper records are of y and the lower ones of y''. The fifth trial gives the proper solution because the y'' and y are zero simultaneously.

channel of the recorder. The ratio of the amplitude of y_1 to P_0 from Fig. 5 is $2.9/8.0 = 0.36$. Since this response was obtained with one unit of $P_0/100$—i.e., with 100 units of P_0—the true deflection of the main mass is $0.36/100 = 0.0036$ feet which is in agreement with the result of reference (4) page 128.

Example 5. Boundary Value Problems—The Thin Uniform Beam with Static Uniform Load

One of the fields in which the differential analyzer is of particular practical use is the solution of boundary value problems. Also the method used is illustrative of numerical methods of obtaining solutions to boundary value problems which can not be solved conveniently in analytical form. As an illustration, the thin uniform beam with static uniform loading and with both ends hinged will be treated. From reference (4) page 179, the differential equation for this case can be written

$$Ap^4y = W, \tag{6}$$

where $A = EI$, y is the deflection of the beam, p denotes differentiation with respect to the distance x along the beam, and W is the load per unit length. The end conditions are $y(0) = y(L) = y''(0) = y''(L) = 0$, where L is the length of the beam. A convenient method of getting a solution which satisfies these end conditions is to arrange a computer to obey equation (6) in which the independent variable becomes time t. The conditions $y(0) = y''(0) = 0$ are imposed by means of switches and the ratio of $y'(0)$ to $y'''(0)$ is varied until at some later time T, the conditions $y(T) = y''(T) = 0$ are satisfied. This then is a solution for the case of both ends hinged.

A computer arrangement which obeys equation (6) follows directly from Fig. 1 in which $B = C = D = E = \beta = \gamma = \delta = 0$ so that the arrangement consists only of amplifiers A_2, A_4, A_6, A_8, A_{10} and A_{12}. Actually, it is possible to use only four amplifiers if properly connected.** Initial conditions are imposed by means of switches which short circuit the feed back condenser of amplifiers A_8 and A_{12} the outputs of which are y'' and y, respectively, and by switches which connect a battery of voltage V_a across the feed back condenser of A_6 and a voltage of value V_b across the condenser of A_{10} the outputs of which are $-y'''$

and $-y'$, respectively. All four switches are opened simultaneously at time $t = 0$. The input at the $x(t)$ terminals of Fig. 1 is a voltage of some convenient value V. The voltage V_a is then varied and solutions tried until a solution which satisfies the end conditions at some later time T is obtained. Figure 6 is a recording of y and y'' for five trial solutions obtained by successive settings of V_a. The fifth trial satisfies the end conditions. Fig. 7 is a recording of y, y', y'' and y''' for the correct solution.

In order to obtain numerical results for a particular problem it is necessary to obtain a relation between the computer length T and the actual length L by making the substitution $t = Tx/L$. The relation is **: $W/EI = (T^4/L^4)V$, where V = the input voltage to the computer and with $1/\alpha = 1$ megohm. Corresponding to any point t in the computer solution the bending moment is given by $EI(T^2/L^2)y''$ and the shear force by $EI(T^3/L^3)y'''$. Since the problem is linear, the displacement, bending moment, etc., can be determined from any loading by simply multiplying the corresponding quantities from the computer solution by the ratio of the desired loading to the computer solution loading calculated from the above relation between W and V. A convenient way to

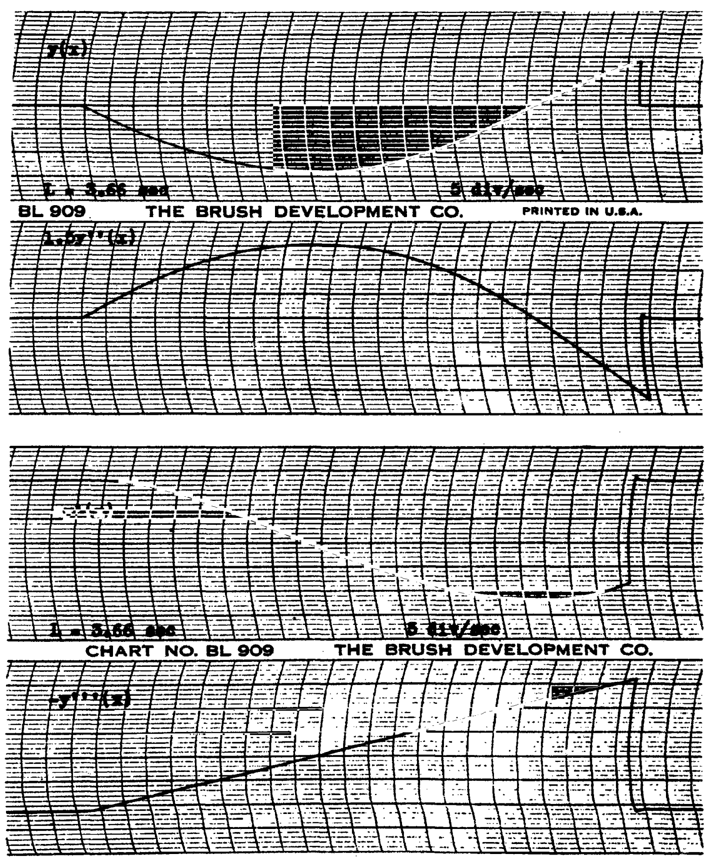


FIG. 7. Recording of y, y', y'', and y''' for a uniform beam with uniform load hinged at the ends.

determine the values of y, y', y'' and y''' from the computer solution is to apply the voltage V directly to each channel of the recorder and thus determine the deflection, R_v, in each channel produced by the voltage V. Then the values of y, y', y'', and y''' are the corresponding deflections divided by the R_v for the respective channel. As an example, consider the recordings of Fig. 7. For the y channel $R_v = 6.0$. From Fig. 7 the maximum deflection of y is about fourteen units. Thus $y_{max} = 14/6.0 = 2.3$ units. Also from the figure, $T = 3.66$ seconds. Hence, from above $W = 180 \ EI/L^4$. Suppose that the problem to be solved is for a beam with $L = 1$, $EI = 1$ and $W = 1$. Thus the computer solution corresponds to $W = 180$. Hence, the value of y_{max} for $W = 1$ is $2.3/180 = 0.013$ units. From reference (7), page 121, the corresponding calculated value is $5/38.4 = 0.013$. Similarly for the y'' channel, $R_v = 5.6$ and from the record $1.5\, y''_{max} = 15$. Hence, $y''_{max} = 15/(1.5 \times 5.6) = 1.8$ units. Thus the maximum bending moment $M_{max} = EI(T^2/L^2)y''_{max} = 24$ which, as before, corresponds to $W = 180$. For $W = 1$, $M_{max} = 24/180 = 0.13$. From reference (7) page 121 the corresponding value is 1/8.

It should be pointed out that it is always possible to adjust the input voltage V (or the resistance $1/\alpha$), each time adjusting the ratio of the two unspecified initial voltages until the end conditions are satisfied, so that the computer length T is numerically equal to the actual length L (or to any other specified value). Other means of supporting the beam such as cantilever, clamped-clamped, etc., can be investigated simply by imposing the proper end conditions. It is also easy to obtain the normal modes of vibrations of beams.[6] **

Conclusion

Many examples of engineering problems such as consecutive reactions,[8] radioactive decay,[9] etc., can be easily demonstrated.** There are also a few simple precautions which must be observed in order to obtain accurate and reliable results.**

The authors are indebted to Professor C. E. Howe of Oberlin College, who, while at the University of Michigan, worked out many computer connections and ran many records some of which are included in this paper. The authors are also indebted to Professor L. L. Rauch of the University of Michigan, for criticism of the manuscript and for assistance in the preparation of the manuscript.

References

(1). Ragazzini, Randall and Russell, IRE, *35*, 444 (1947).

(2) Frost, Electronics, *21*, 116, July (1948), see also Korn, Electronics, *21*, 122, April (1948); Macnee, IRE, *37*, 1315 (1949).

(3). University of Michigan, External Memorandum No. UMM-28 (April 1, 1949), *Investigation of the Utility of an Electronic Analogue Computer in Engineering Problems* USAF Project MX-794 (Contract W33-038-ac-14222), by Hagelbarger, Howe and Howe.

(4). Den Hartog, "Mechanical Vibrations" (Second Edition, 1940), McGraw-Hill.

(5). Lauer, Lesnick, and Matson, "Servomechanism Fundamentals" (1947), McGraw-Hill.

(6). Timoshenko, "Vibration Problems in Engineering" (Second Edition, 1937) Van Nostrand.

(7). Hudson, "The Engineers' Manual."

(8). Hougen and Watson, "Chemical Process Principles," Part III (1947), Wiley, page 829.

(9). Rasetti, "Elements of Nuclear Physics" (1936), Prentice-Hall, page 28.

TIMELY TIPS

Wave Velocities Above the Velocity of Sound

By R. C. BINDER

Professor of Mechanical Engineering, Purdue University

In various courses involving the flow of a compressible fluid there may arise a pedagogical problem concerning the velocity of a pressure wave. For example, students may ask if a pressure wave can move faster than the velocity of sound An instructor, particularly in an undergraduate course, may like to have available a relatively simple and short quantitative analysis to answer questions of this sort. The following discussion outlines a quantitative study which does not involve differential equations. This study may be of help to instructors confronted with this pedagogical problem.

Imagine a cylindrical tube with rigid walls filled with a gas initially at rest, as illustrated in Fig. 1a. It will be assumed that the motion is one-dimensional, with no heat transfer, and no friction. Picture the pressure wave caused by the motion of the piston to the right in the tube. The piston moves with the velocity V_2; just ahead of the piston the gas static pressure is p_2. Some distance ahead of the piston the gas is at rest, the velocity V_1 is zero, and the static pressure is p_1.

There is a pressure wave travelling to the right with the velocity a because of the motion of the piston. Across this compression wave there is a sudden change in static pressure from p_2 to p_1.

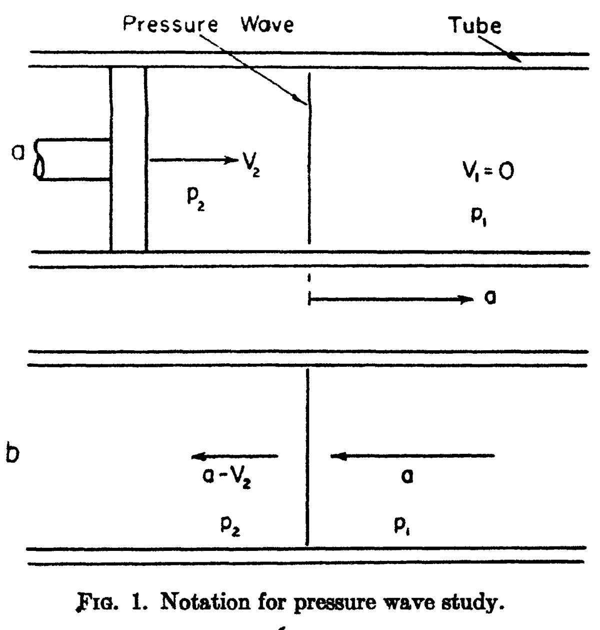


FIG. 1. Notation for pressure wave study.

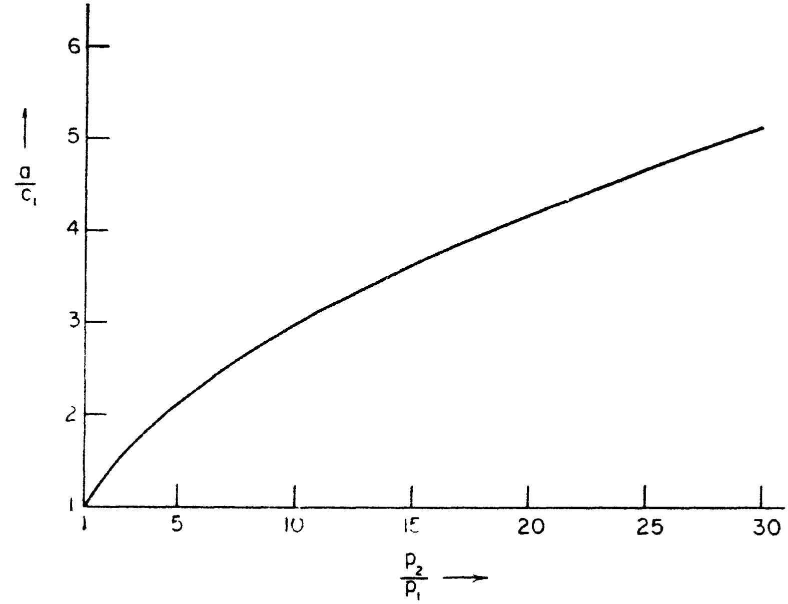


FIG. 2. Wave velocity ratio versus pressure ratio, for $k = 1.4$.

Figure 1a illustrates the pressure wave at a certain instant at a certain position in the tube. Picture an observer moving along with the wave, as illustrated in Fig. 1b. The same relative motion can be obtained by superimposing the velocity $-a$ on the flow shown in Fig. 1a.

In Fig. 1b the gas approaches the compression wave with a velocity a to the left, a static pressure p_1, and a density ρ_1. After the wave the velocity is $(a - V_2)$, the pressure is p_2, and the density is ρ_2. Let A represent the cross-sectional area of the tube.

The equation of continuity becomes

$$Aa\rho_1 = A\rho_2(a - V_2). \qquad (1)$$

The momentum or dynamic equation gives

$$(p_1 - p_2)A = A\rho_1 a[(a - V_2) - a]. \qquad (2)$$

The energy equation gives

$$\frac{(a - V_2)^2 - a^2}{2} = \frac{k}{k-1}\left(\frac{p_1}{\rho_1} - \frac{p_2}{\rho_2}\right), \qquad (3)$$

where k is the ratio of specific heats.

Equation (1) can be employed to give an expression for ρ_2 that can be substituted in Equation (3). Equation (2) can be used to give an expression for V_2 which can be substituted in Equation (3). Let

$$c_1 = \sqrt{\frac{kp_1}{\rho_1}}.$$

The final result of eliminating ρ_2 and V_2 is

$$\frac{a}{c_1} = \left(\frac{k-1}{2k} + \left(\frac{p_2}{p_1}\right)\left(\frac{k+1}{2k}\right)\right)^{\frac{1}{2}}. \qquad (4)$$

Consider first the special case in which p_2/p_1 equals 1. Then Equation (4) shows that $a = c_1$. The velocity c_1 is variously called the "acoustic" velocity or the velocity of "sound" for the gas having a density ρ_1 and a static pressure p_1.

We could say that the pressure change is infinitesimal across a pressure wave moving with the acoustic velocity. If the pressure change $p_2 - p_1$ is finite, however, the velocity of the compression wave is *higher* than the acoustic velocity. This fact is demonstrated by the plot in

Fig. 2 showing the velocity ratio a/c_1 as a function of p_2/p_1. At the higher pressure ratios the velocity a is considerably higher than the acoustic velocity c_1. In other words, we could say that the acoustic velocity is the *lowest* velocity of a compression wave.

A qualitative illustration can be provided by studying a blunt nose projectile moving through air at a supersonic speed. Ahead of the nose of the projectile is a normal compression shock (part of the bow wave) which is moving with the speed of the projectile. This compression wave moves at a speed higher than the velocity of sound. Across the compression wave there is a finite change in pressure.

Formulas for the Center of Hydrostatic Pressure

By GEORGE P. LOWEKE

Assistant Professor of Engineering Mechanics, Wayne University

The determination of the vertical location of the center of pressure on plane surfaces is usually the only formula derived in textbooks on hydraulics and fluid mechanics. Little attention is given to the determination of the lateral location. This can be determined from a median line, if one exists, or from the symmetry of the figures which are ordinarily encountered in engineering. No formula is therefore offered for locating the center of pressure laterally as is done in the vertical determination of this point. In cases where the fiugres are not symmetircal, however, the engineer usually has only one recourse, that is to proceed from the beginning of the problem by determining a pressure moment by integration. It is interesting to note that the horizontal and vertical location of the center of pressure can be found from formulas that are essentially the same, and could always be treated together when teaching the subject rather than to consider the lateral location as a separate problem.

The formula for the vertical location of the center of pressure, as derived in all texts treating the subject, is,

$$\epsilon_{\bar{y}} = \frac{I_{\bar{y}}}{\bar{y}A},$$

where $\epsilon_{\bar{y}}$ is the location of the center of pressure below the centroid of the area, $I_{\bar{y}}$ is the second moment of the area about an axis through the centroid parallel to the surface of the liquid, and $\bar{y}A$ is the first moment of the area about an axis in the plane of the area and lying in the surface of the liquid.

The location of the center of pressure laterally is defined by the equation

$$X_{\text{c.p.}} = \frac{M}{F},$$

where M is the pressure moment taken about any vertical axis and F is the hydrostatic force on the plane. For an inclined plane as shown in Fig. 1, integrating over the area, gives

$$M = \int\int wyx \sin\theta \, dy \, dx,$$
$$= w \sin\theta \, I_{xy},$$

where I_{xy} is the product of inertia of the area about the x and y axes. Also

$$F = w \sin\theta \int\int y \, dy \, dx,$$
$$= w \sin\theta \, \bar{y}A.$$

By definition

$$X_{\text{c.p.}} = \frac{w \sin\theta \, I_{xy}}{w \sin\theta \, \bar{y}A} = \frac{I_{xy}}{\bar{y}A}.$$

This form can be reduced by the paral-

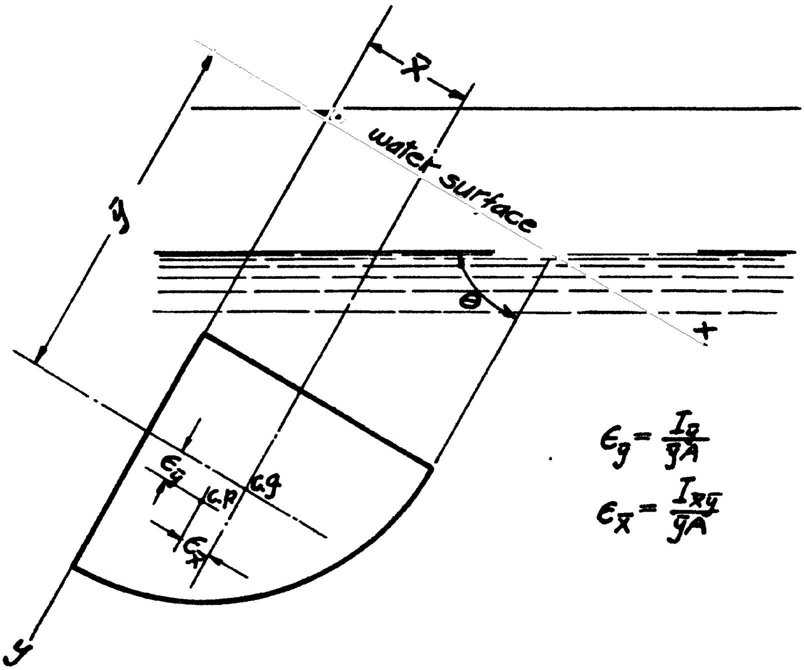


FIG. 1. Showing the vertical and horizontal location of the center of pressure on a submerged plane area by analogous formulas.

lel axis theorem, since

$$I_{xy} = I_{\bar x \bar y} + \bar x \bar y A,$$

where $I_{\bar x \bar y}$ is the product of inertia about parallel axes through the centroid of the immersed plate at distance $\bar x$, $\bar y$ from the original axes.
Then

$$X_{\text{c.p.}} = \frac{I_{\bar x \bar y} + \bar x \bar y A}{\bar y A} = \frac{I_{\bar x \bar y}}{\bar y A} + \bar x.$$

Putting $X_{\text{c.p.}} - \bar x = \epsilon_{\bar x}$ the lateral displacement of the center of pressure from the centroid is

$$\epsilon_{\bar x} = \frac{I_{\bar x \bar y}}{\bar y A}.$$

The similarity of the equations for $\epsilon_{\bar x}$ and $\epsilon_{\bar y}$ establishes uniformity in the computation of these quantities and makes it easier for the student to retain the whole concept. The quantity $I_{\bar y}$ is usually obtainable form handbooks. In cases where $I_{\bar x \bar y}$ cannot be readily obtained, this method permits the computation of the center of pressure entirely by the use of standard techniques easily obtainable in all standard works on elementary mechanics. When the submerged plane figure is symmetrical about a vertical axis, the product of inertia about axes through the centroid is zero, in which case ϵ_x becomes zero.

Candid Comments

Dear Professor Bronwell:

I was interested to note under "Candid Comments" in the March issue of the JOURNAL an article by Professor Snader of Norwich University entitled "The First Engineering School."

We all realize that Americans have a remarkable propensity for claiming firsts, biggests, bests, etc., in practically all fields of man's endeavors. Therefore it was with a mixed feeling of amusement and injured pride that I read the claim that Norwich was the first educational institution in the country to teach civil engineering. It so happens, that this distinction—claimed by both Rensselaer and Norwich—actually goes back before either of these institutions were founded, to the United States Military Academy at West Point.

Founded in 1802 by an Act of Congress, West Point was initially a school for Engineers and Artillerists. However, without adequate support, it struggled along as best it could until the War of 1812 suddenly focussed the attention of the Congress on the Military Academy. An Act was passed in April of 1812 reorganizing the Academy and establishing among others, the Professorship of Engineering. It is interesting to note that Alden Partridge (who founded Norwich in 1820) graduated from West Point in 1806, was Professor of Engineering there from 1813–15, and then was Superintendent until 1817.

Joseph Gardner Swift, the first graduate of West Point (Class of 1802) resigned from the service in 1818 to become a distinguised civil engineer. Other early graduates who became civil engineers, included W. G. McNeill, Class of 1817; Andrew Talcott 1818, Jonathan Prescott, and Charles Dimmock of the Class of 1821, 5 graduates in 1822, 2 in 1823 and 4 in 1824. To bear out further the fact that even in those early days, West Point produced something besides soldiers (and engineers), consider the following: Horace Webster, of the Class of 1818 was President of College, City of New York from its founding in 1848 until 1869. Edward H. Courtenay, Class of 1821, was for eleven years, the Professor of Mathematics at the University of Virginia. Thomas R. Ingalls, Class of 1822, was President of Jefferson College, in Louisiana.

Yours sincerely,

ELVIN R. HEIBERG,
Colonel, USA,
Professor of Mechanics

1951 Oak Ridge Summer Symposium

"The Role of Engineering in Nuclear Development," sponsored jointly by the Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies. Oak Ridge, Tenn., August 27–September 7, 1951. For information write

University Relations Division,
Oak Ridge Institute of
Nuclear Studies, Inc.,
P. O. Box 117,
Oak Ridge, Tenn.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner, Carnegie Institute
Illinois-Indiana	Northwestern University	May 12, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University	Feb. 6, 1951	R. B. Allen, University of Maryland
	U. S. Naval Post Graduate School	May 12, 1951	
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
* North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	May 4–5, 1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 27–28, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
* Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 5–6, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

New Members

AGGELER, CECIL J., Instructor in Engineering, City College of San Francisco, San Francisco, Calif. A. E. Edstrom, H. R. Edmison.

ALLEN, JOHN E., Professor and Head, Geology Dept., New Mexico School of Mines, Socorro, N. Mex. J. A. Schufle, M. F. Stubbs.

AVERITT, WILLIAM K., Assistant Professor of Chemical Engineering, Southwestern Louisiana Institute, Lafayette, La. H. R. Mason, F. W. ZurBurg.

BORNEMANN, ALFRED, Professor of Metallurgy, Stevens Institute of Technology, Hoboken, N. J. R. O. Vuilleumier, K. J. Moser.

BORG, GRANT K., Assistant Professor of Civil Engineering, University of Utah, Salt Lake City, Utah. H. S. Carter, R. L. Sloane.

BREDENDIECK, HINRICH, Assistant Professor, Institute of Design, Illinois Institute of Technology. J. T. Rettaliata, L. E. Grinter.

BUTLER, EDWARD W., Director, Radio Division, Federal Telephone and Radio Corp., Clifton, New Jersey. C. E. Tucker, H. R. Hazen.

CLINE, JOHN E., Instructor in Chemistry, Philadelphia Textile Institute, Philadelphia 44, Pennsylvania. C. E. Fink, G. S. Sasin.

COLEMAN, JOHN B., Associate Professor of Electrical Engineering, University of Buffalo, Buffalo, N. Y. A. T. Zalinu, P. E. Mohn.

CORTRIGHT, DONALD N., Assistant Professor of Civil Engineering, Washington University, St. Louis, Mo. R. E. Stout, J. W. Hubler.

CRANK, ROBERT E., Instructor in Mechanical Engineering, Kansas State College, Manhattan, Kansas. A. O. Flinner, B. B. Brainard.

CREUTZ, E., Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. J. W. Graham, Jr., D. F. Miner.

CUYKENDALL, TREVOR R., Professor of Engineering Physics, Cornell University, Ithaca, N. Y. D. F. Gunder, A. B. Credle.

DURAND, JACK A., Instructor in Aeronautical Engineering, Parks College of Aero. Tech., East St. Louis, Illinois. N. C. Beck, D. H. Webber.

EIKNER, DONALD E., University Relations, Westinghouse Electric Corp., East Pittsburgh, Pa. J. C. McKeon, Guy Kleis.

ELMERGREEN, GEORGE L., Assistant Professor of Electrical Engineering, University of Wisconsin, Milwaukee 16, Wis. J. G. VanVleet, W. M. Christman, Jr.

FOECKE, HAROLD A., Instructor in Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. C. C. Whipple, Ernst Weber.

FREVERT, RICHARD K., Professor of Agricultural Engineering, Iowa State College, Ames, Iowa. H. J. Barre, H. Beresford.

GAGE, JAMES A., Assistant Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. R. W. Leutwiler, Jr., C. A. Gilpin.

GRUMMANN, HERBERT R., Associate Professor of Aeronautical Engineering, Parks College of Aero. Tech., St. Louis Univ., East St. Louis, Ill. N, C. Beck, V. J. Blum.

GUPTON, JAMES M., Senior Instructor, Machine Shop, School of Tech., University of Houston, Houston, Texas. J. E. Hoff, T. E. McCullick.

GUTHRIE, WILLIAM S., Associate Professor of Mechanical Engineering, Texas A. & M. College, College Station, Texas. R. M. Wingren, C. W. Crawford.

HARKER, RALPH J., Associate Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. P. H. Hyland, R. A. Ragatz.

HARMS, JOHN, Education and Training Specialist, Personnel Div., Naval Research Lab., Washington, D. C. K. C. Harder, R. M. Hogan.

HERRMANN, ERNEST E., Superintendent, U. S. Naval Postgraduate School, Annapolis, Md. P. J. Kiefer, H. M. Wright.

HIGGINS, FRANCIS V., Assistant Professor of Mechanics, Fenn College, Cleveland, Ohio. A. R. Deptula, J. Arendt, Jr.

HOOVER, WILLIAM G., Associate Professor of Electrical Engineering, Stanford Uni-

versity, Stanford, Calif. H. Skilling, B. M. Green.

HORN, EARL R., Lecturer, Aeronautical Engineering, Parks College of Aeronautical Technology, East St. Louis, Ill. N. C. Beck, D. H. Webber.

HUBBARD, E. CLYDE, Instructor in Aeronautical Engineering, Parks College of Aero. Tech., East St. Louis, Ill. N. C. Beck, D. H. Webber.

KAYE, JOHN, Assistant Professor of Mechanical Engineering, George Washington University, Washington 6, D. C. C. E. Greeley, R. G. Trumbull.

KELLY, MERLE J., Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. W. H. Erickson, C. L. Cottrell.

KIRKLIN, BERNARD C., Technical Instructor, Automotive Dept., Schools of Technology, University of Houston, Houston, Texas. J. T. Hoff, H. E. McCallick.

KLEKOTKA, JOHN A., Acting Head, Electrical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, J. J. Gallen.

KOSNER, EDWARD F., Associate Professor of Tool Engineering, Allied Institute of Technology, Cicero, Illinois. H. H. Katz, W. J. Luzadder.

KREY, ROGER A., Instructor in Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. M. G. Mochel, W. H. Allison.

LILLIE, JOHN, Instructor in Engineering, Sacramento Junior College, Sacramento, Calif. E. B. Weinberg, A. S. Levens.

MANAHAN, JERVIS R., Assistant Professor of Woodworking, School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

MASSER, CHESTER L., Senior Tech. Instructor in Electronics, School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

MCFERRIN, CHARLES H., Laboratory Instructor in Mechanical Engineering, Tri-State College, Angola, Ind. J. G. Radcliffe, J. C. Humphries.

MCGAW, ALEX J., Professor and Head, Civil Engineering Dept., University of Wyoming, Laramie, Wyoming. H. T. Person, E. J. Lindahl.

MENDOUSSE, JEAN S., Associate Professor of Civil Engineering, The Catholic University of America, Washington, D. C. F. Biberstein, J. C. Michalowicz.

MENZEL, T. ARTHUR, College Employment Coordinator, Personnel Dept., New York Telephone Company, New York, N. Y. E. C. Lawson, Jr., D. L. Arm.

MILLS, BARRISS, Professor and Head, English Dept., Purdue University, Lafayette, Ind. P. Fatout, H. B. Knoll.

MILLS, ERNEST E., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferretti, J. W. Zeller.

MOE, DENNIS L., Research Engineer, Agricultural Engrg. Dept., South Dakota State College, Brookings, S. Dak. E. E. Johnson, J. N. Cheadle.

RANOV, THEODOR, Associate Professor of Drawing, Mechanics, and Design, School of Engrg., University of Buffalo, Buffalo, N. Y. R. L. Pleuthner, F. P. Fischer.

REED, CHARLES O., JR., Instructor in Chemical Engineering, Missouri School of Mines, Rolla, Mo. F. H. Conrad, N. L. Smith.

ROTHAUGE, CHARLES H., Assistant Professor of Electrical Engineering, U. S. Naval Postgraduate School, Annapolis, Md. C. V. Terwilliger, H. M. Wright.

ROWLETT, WM. C., Director, School of Automotive Trade, University of Houston, Houston, Texas. J. E. Hoff, H. E. McCallick.

RYAN, WALTER G. H., Associate Professor of Personnel Relations, Newark College of Engineering, Newark, N. J. F. N. Entwisle, E. C. Lawson, Jr.

SANKS, ROBERT L., Assistant Professor of Civil Engineering, University of Utah, Salt Lake City, Utah. H. S. Carter, R. L. Sloane.

SATTERLEY, WILLIAM O., Assistant Professor of General Engineering, Purdue University, Lafayette, Ind. Justus Rising, H. A. Bolz.

SIMS, A. RAY, Dean, Schools of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

SMITH, ADAM J., Associate Professor of Mathematics, Montana School of Mines, Butte, Montana. D. W. McGlashan, A. E. Adami.

SMITH, BARNARD E., Assistant Professor of Mechanical Engineering, University of North Dakota, Grand Forks, N. Dak. P. J. Reiten, B. J. Fox.

SMITH, LLOYD P., Professor and Head, Physics Dept., Cornell University, Ithaca, N. Y. F. M. Dawson, A. B. Bronwell.

SPROUSE, JAMES H., JR., Instructor in Civil Engineering, University of New Mexico, Albuquerque, N. Mex. C. B. Thompson, J. L. Guy.

STARK, LAWRENCE E., Assistant Professor of Engineering Drawing, Texas A. & M. College, College Station, Texas. W. E. Street, B. F. K. Mullins.

STOTTS, OSMAN O., Instructor in Diesel Engineering, School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

TACHAU, HERMAN, Assistant Professor of Civil Engineering, State University of Iowa, Iowa City, Iowa. J. W. Howe, C. J. Posey.

THOMPSON, ALVIN J., Professor and Head, Dept. of Mining and Metallurgy, New Mexico School of Mines, Socorro, New Mex. M. F. Stubbs, J. Hartry.

TSANG, NGEU FAUNG, Assistant Professor of Electrical Engineering, University of Minnesota, Minnesota 14, Minn. H. E. Hartig, S. C. Larson.

WARNER, CLYDE K., JR., Instructor in Civil Engineering, University of Louisville, Louisville, Ky. W. R. McIntosh, W. B. Wendt.

WEITER, ELMER J., Assistant Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Matar, W. D. Bliss.

WHITTINGTON, HARRY K., Assistant Professor of Diesel Engineering, School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

WIENER, WILLIAM K., Senior Instructor, Automotive Dept., School of Technology, University of Houston, Houston, Texas. J. E. Hoff, H. E. McCallick.

WILLSON, WILLIAM H., Director of Ref. & Air. Cond., School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

WILSON, HENRY C., Head of Radio Dept., School of Technology, University of Houston, Houston, Texas. M. L. Ray, H. E. McCallick.

WINTERKORN, HANS F., Associate Professor of Civil Engineering, Princeton University, Princeton, N. J. Harry Rubey, P. Kissam.

WISLICENUS, GEORGE F., Professor and Head, Mechanical Engineering Dept., The Johns Hopkins University, Baltimore, Md. J. T. Thompson, W. C. Boyer.

ZOLLER, J. HAROLD, Assistant Professor of Civil Engineering, University of Wyoming, Laramie, Wyoming. H. T. Person, E. J. Lindahl.

524 new members this year

College Notes

The first of a series of special summer graduate programs in engineering will be offered by **North Carolina State College**, during the 12-week period June 11–August 31. The new programs are designed to make advanced courses available to anyone interested, and to enable graduate students to obtain a Master of Science degree with three summers' work. Conceived as a teacher-aid program, the session will be subsidized by the General Education Board, with the intention of providing an opportunity for young engineering teachers in the South to obtain advanced knowledge and broader concepts of their chosen field of scientific activity. Three Departments—Ceramic Engineering, Chemical Engineering, and Electrical Engineering—will each offer a full program of graduate courses, and advanced work in Mathematics and Physics will also be available. In a series of three such summer sessions, a complete and integrated program is achieved, fulfilling all requirements for an M.S. degree in these three fields. Credits may also be applied toward a Ph.D. degree, and are transferable.

Subject Index 1950-1951

Author Index